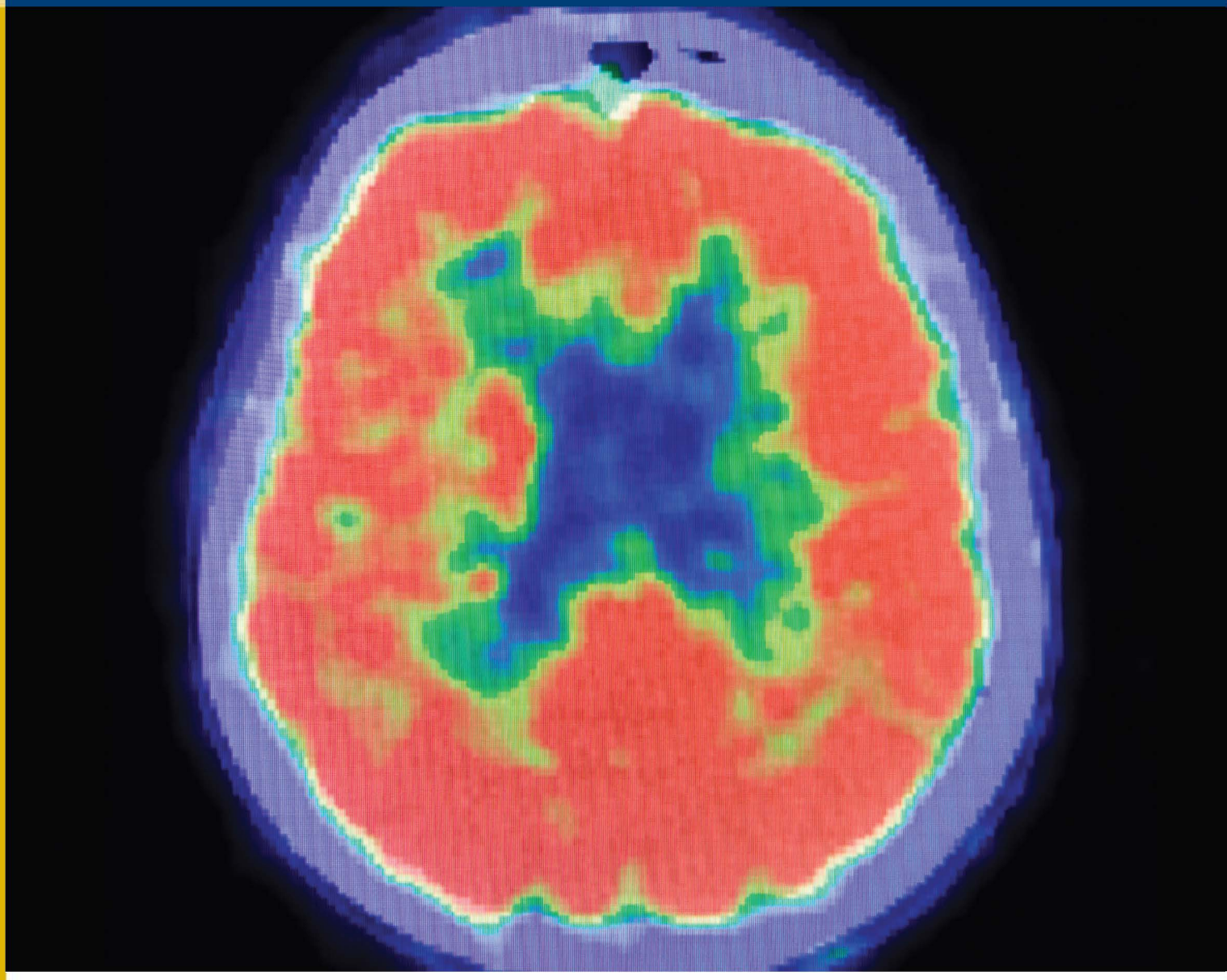
The Royal Australasian College of Physicians

Nuclear Medicine

Advanced Training Curriculum

Adult Medicine Division
Paediatrics & Child Health Division



Australasian Association of Nuclear Medicine Specialists

Australian and New Zealand Association of Physicians in Nuclear Medicine (Inc)

The Royal Australasian College of Physicians

Physician Readiness for Expert Practice (PREP) Training Program

Nuclear Medicine Advanced Training Curriculum

TO BE USED IN CONJUNCTION WITH:

Basic Training Curriculum – Adult Internal Medicine

Basic Training Curriculum – Paediatrics & Child Health

Professional Qualities Curriculum

ACKNOWLEDGEMENTS

Royal Australasian College of Physicians (RACP) Fellows, trainees and staff have contributed to the development of this curriculum document.

The College specifically thanks those Fellows and trainees who have generously contributed to the development of these curriculum documents through critical comments drawn from their knowledge and experience and the donation of their time and professional expertise. This curriculum is based on, and includes, material from the Australian and New Zealand Association of Physicians in Nuclear Medicine (ANZAPNM) *Syllabus for Advanced Training in Nuclear Medicine (2001; 2nd Edition 2005)*, developed by the following ANZAPNM members:

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with advice and assistance from the University of New South Wales School of Medical Education staff (Dr Peter Harris, Dr Chris Hughes and Dr Alexandra Smith).

The current curriculum was developed during 2010 and 2011 and was overseen by the Curriculum Review Committee of ANZAPNM:

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This curriculum has been endorsed by the Joint Specialist Advisory Committee (JSAC) in Nuclear Medicine of the RACP and the Royal Australian and New Zealand College of Radiologists (RANZCR). The RACP gratefully acknowledges the contribution of the ANZAPNM to the development of this curriculum.

The process was managed by the Curriculum Development Unit within the College's Education Deanery, who designed the document, drafted non-clinical content material, organised and facilitated writing workshops, developed resource materials, and formatted the final document.

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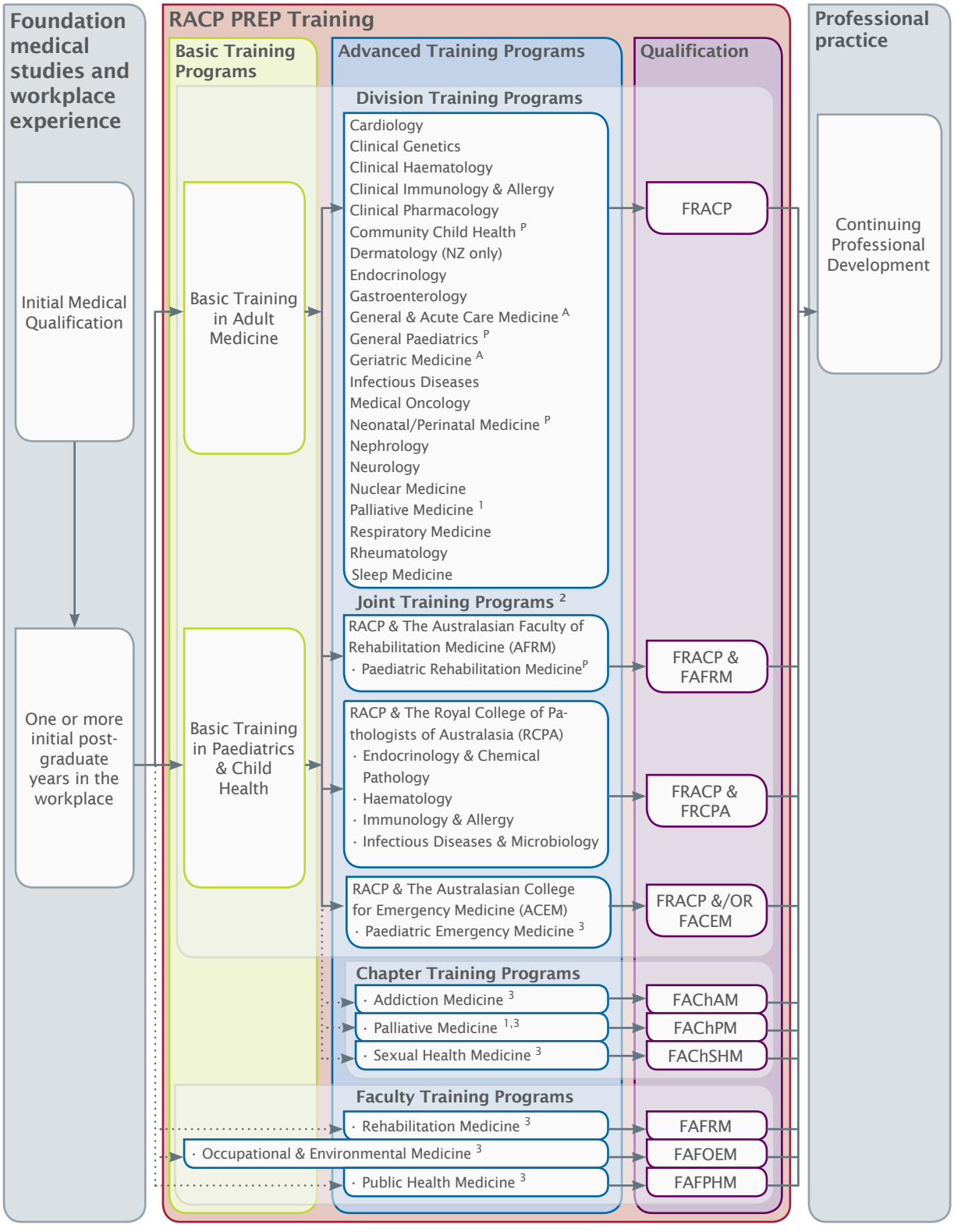
Please note: No Domains, Themes or Learning Objectives have been updated for this edition; design changes ONLY.

RACP FELLOWSHIP TRAINING PATHWAYS AND THE CONTINUUM OF LEARNING



P Trainees must complete Basic Training in Paediatrics & Child Health to enter this program.
A Trainees must complete Basic Training in Adult Medicine to enter this program.
1 Trainees who have entered Advanced Training in Palliative Medicine via a RACP Basic Training Program will be awarded FRACP upon completion and may subsequently be awarded FAChPM. Trainees who have NOT entered Advanced Training in Palliative Medicine via a RACP Basic Training Program will only be awarded FAChPM upon completion.
2 The Child & Adolescent Psychiatry Joint Training Program with the Royal Australian and New Zealand College of Psychiatrists (RANZCP) is currently under review by the RACP and RANZCP and closed to new entrants at present.
3 Alternative entry requirements exist for these training programs; please see the corresponding PREP Program Requirements Handbook for further information.

NB1: This diagram only depicts training programs that lead to Fellowship. Please see the RACP website for additional RACP training programs.
NB2: For further information on any of the above listed training programs, please see the corresponding PREP Program Requirements Handbook.

OVERVIEW OF THE SPECIALTY

Nuclear medicine is the medical specialty that utilises the nuclear properties of radioactive nuclides to make diagnostic evaluations of the anatomical and/or physiological conditions of the body and to provide therapy with unsealed radioactive sources.

CURRICULUM OVERVIEW

Nuclear Medicine – Advanced Training Curriculum

This curriculum outlines the broad concepts, related learning objectives and the associated theoretical knowledge, clinical skills, attitudes and behaviours required and commonly utilised by nuclear medicine specialists within Australia and New Zealand.

The purpose of Advanced Training is for trainees to build on the cognitive and practical skills acquired during Basic Training. At the completion of the Nuclear Medicine Advanced Training Program, trainees should be competent to provide, at consultant level, unsupervised comprehensive medical care in nuclear medicine.

Attaining competency in all aspects of this curriculum is expected to take two to three years of training. It is expected that all teaching, learning and assessment associated with the Nuclear Medicine Advanced Training Curriculum will be undertaken within the context of the specialist's everyday clinical practice and will accommodate discipline-specific contexts and practices as required. As such it will need to be implemented within the reality of current workplace and workforce issues and the needs of health service provision.

There may be learning objectives that overlap with or could easily relate to other domains; however, to avoid repetition, these have been assigned to only one area. In practice, it is anticipated that within the teaching/learning environment the progression of each objective would be explored.

In the advanced phase of training covered by this curriculum, the trainee will be working in an accredited training location under the supervision of an experienced nuclear medicine specialist.

The themes within this curriculum concentrate on the more technical aspects of nuclear medicine practice. The themes are generally arranged so that they build progressively upon the skills and knowledge developed while following this curriculum.

Many learning objectives draw upon a detailed knowledge of anatomy, physiology and pathology. Resources to support development of this underpinning knowledge are usually listed at the end of the relevant theme. Further areas of required knowledge are referred to in some learning objectives, and in-depth study of these areas will be required if the required learning objective standards are to be achieved.

The degree to which the nuclear medicine specialist needs to develop technical skills is to some extent location dependent. The trainee should consult with his or her supervisor for advice on the interpretation of the word 'perform' in learning objectives and skills lists.

Three standards are used in the learning objectives, depending on the requirements of the area being addressed:

Standard	Description
Independent practice (I)	The standard of an independent professional practitioner
Assisted practice (A)	The standard of a professional nuclear medicine practitioner performing with the advice and assistance of an experienced nuclear medicine specialist

Well-informed advice and referral (WI)	The standard of a well-informed professional nuclear medicine practitioner responding to the queries of a referring medical practitioner, and referring appropriately

Note: The curricula should always be read in conjunction with the relevant College Training Handbook available on the College website.

Professional Qualities Curriculum

The Professional Qualities Curriculum (PQC) outlines the range of concepts and specific learning objectives required by, and utilised by, all physicians, regardless of their specialty or area of expertise. It spans both the Basic and Advanced Training Programs and is also utilised as a key component of the Continuing Professional Development (CPD) program.

Together with the various Basic and Advanced Training Curricula, the PQC integrates and fully encompasses the diagnostic, clinical, and educative-based aspects of the physician's/paediatrician's daily practice.

Each of the concepts and objectives within the PQC will be taught, learnt and assessed within the context of everyday clinical practice. Thus it is important that they be aligned with, and fully integrated into, the learning objectives within this curriculum.

Additional resource: trainees entering Nuclear Medicine Advanced Training from radiology may refer to the Non-Medical Expert Role module of the *Radiodiagnosis Training Program Curriculum* of the RANZCR.

EXPECTED OUTCOMES AT THE COMPLETION OF TRAINING

Graduates from this training program will be equipped to function effectively within the current and emerging professional, medical and societal contexts. At the completion of the Advanced Training Program in Nuclear Medicine, as defined by this curriculum, it is expected that graduates of the program will have developed the clinical skills and have acquired the theoretical knowledge for competent nuclear medicine practice. It is expected that a new nuclear medicine specialist will have:

- high level skills in the technical processes and routine procedures undertaken in the specialty
- an approach to clinical judgement and to the practice of nuclear medicine that focuses on the clinical setting and on the pathophysiological processes involved in each case
- the ability to apply a well-developed and appropriately structured knowledge base in internal and nuclear medicine and correlative imaging to the primary areas of professional practice of the specialty
- research skills to support ongoing evidence-based practice in the specialty
- high level communication skills, especially in the explanation and reporting of procedures and studies employed in the specialty. Graduates of the program will be able to employ these skills with referring doctors, other health professionals, and with patients and members of their families
- well-developed educational skills to support a teaching role in areas related to the specialty, especially with medical students, junior staff, allied health professionals, and members of the public
- quality assurance skills to enable the implementation and ongoing evaluation of nuclear medicine practice to a high technical and professional standard
- organisational skills to support independent practice in nuclear medicine, as well as contributions to and leadership of hospital teams
- a high standard of ethical and professional behaviour as befits a Fellow of the RACP or the RANZCR.

CURRICULUM THEMES AND LEARNING OBJECTIVES

Each of the curriculum documents has been developed using a common format, thereby ensuring a degree of consistency and approach across the spectrum of training.

Domains

The domains are the broad fields which group common or related areas of learning.

Themes

The themes identify and link more specific aspects of learning into logical or related groups.

Learning Objectives

The learning objectives outline the specific requirements of learning. They provide a focus for identifying and detailing the required knowledge, skills and attitudes. They also provide a context for specifying assessment standards and criteria as well as providing a context for identifying a range of teaching and learning strategies.

LEARNING OBJECTIVES TABLES

DOMAIN 1	SCIENTIFIC BASIS OF NUCLEAR MEDICINE
Theme 1.1	Basic Sciences
Learning Objectives	
1.1.1	Describe anatomy and anatomical variants as relevant to nuclear medicine
1.1.2	Describe pathophysiology as relevant to nuclear medicine
1.1.3	Describe pathology as relevant to nuclear medicine
Theme 1.2	Principles of Imaging and Nuclear Medicine Scanning
Learning Objectives	
1.2.1	Apply imaging and scanning techniques
Theme 1.3	Professional Practice
Learning Objectives	
1.3.1	Describe the safety and quality requirements of nuclear medicine practice

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.1	Cardiovascular Nuclear Medicine
Learning Objectives	
2.1.1	Supervise and interpret resting and exercise ECGs
2.1.2	Supervise and interpret stress testing using pharmacological agents
2.1.3	Assess coronary artery disease using SPECT radiopharmaceuticals
2.1.4	Assess ventricular function using radionuclide ventriculography
2.1.5	Assess congenital heart disease using radiolabelled shunt studies
2.1.6	Perform I-123 MIBG adrenergic cardiac imaging studies
2.1.7	Discuss the role of complementary imaging techniques for cardiac disease
2.1.8	Discuss the role of CTCA in the management of coronary artery disease
2.1.9	Assess coronary artery disease using PET
Theme 2.2	Endocrine Nuclear Medicine
Learning Objectives	
2.2.1	Assess thyrotoxicosis
2.2.2	Assess nodular thyroid disease
2.2.3	Assess hyperparathyroidism
2.2.4	Assess adrenal hypersecretory syndromes using radiolabelled tracers
2.2.5	Discuss the role of complementary imaging techniques for endocrine disease
Theme 2.3	GI Nuclear Medicine
Learning Objectives	
2.3.1	Assess GI motility disorders
2.3.2	Assess hepatic lesions
2.3.3	Assess gallbladder and biliary function using hepatobiliary scans
2.3.4	Assess GI haemorrhage
2.3.5	Assess inflammatory bowel disease (IBD) and intra-abdominal sepsis
2.3.6	Assess abnormal splenic function using Tc-99m labelled tracers
2.3.7	Assess hepatic artery catheters and peritoneal-venous shunts using Tc-99m labelled tracers

2.3.8	Describe the use of salivary and lacrimal gland imaging
2.3.9	Assess GI disease using complementary GI imaging techniques
Theme 2.4	Genitourinary Nuclear Medicine
Learning Objectives	
2.4.1	Assess urinary tract obstruction using renal scans
2.4.2	Assess renal tract infection
2.4.3	Assess renovascular hypertension
2.4.4	Assess a renal transplant patient
2.4.5	Assess renal failure
2.4.6	Discuss the role of complementary imaging techniques for genitourinary disease
Theme 2.5	Infection and Inflammation Nuclear Medicine
Learning Objectives	
2.5.1	Assess infection and inflammation using nuclear medicine techniques
2.5.2	Recognise the emerging role of PET in the assessment of inflammation or infection
Theme 2.6	In Vitro Nuclear Medicine Techniques
Learning Objectives	
2.6.1	Assess patients using C-14 urea breath tests to evaluate *Helicobacter pylori* infection
2.6.2	Assess patients using C-13/14 breath tests to evaluate intestinal absorption
2.6.3	Assess patients using Cr-51 EDTA, Tc-99m DTPA to evaluate renal function
2.6.4	Discuss the role and use of Cr-51 RBCs to evaluate GI bleeding
Theme 2.7	Musculoskeletal Nuclear Medicine
Learning Objectives	
2.7.1	Describe techniques of bone scintigraphy and PET imaging
2.7.2	Assess musculoskeletal trauma
2.7.3	Assess metabolic bone disease
2.7.4	Assess skeletal infection
2.7.5	Assess prosthetic joint replacements
2.7.6	Assess patients following spinal surgery

2.7.7	Assess arthritis and related conditions
2.7.8	Discuss the role of complementary musculoskeletal imaging modalities
Theme 2.8	Neurological Nuclear Medicine
Learning Objectives	
2.8.1	Assess brain function using SPECT and PET
2.8.2	Assess disorders of CSF flow and suspected CSF leaks using scintigraphic techniques
2.8.3	Identify emerging brain SPECT and PET techniques
2.8.4	Assess impaired neurological function using complementary imaging techniques
Theme 2.9	Oncological Nuclear Medicine
Learning Objectives	
2.9.1	Assess oncological disorders with F-18 FDG PET
2.9.2	Assess patients with lung cancer
2.9.3	Assess patients with GI malignancies
2.9.4	Assess patients with breast cancer
2.9.5	Assess patients with head and neck malignancies
2.9.6	Assess patients with melanoma
2.9.7	Assess patients with neuroendocrine tumours
2.9.8	Assess patients with lymphoma and other haematological malignancies
2.9.9	Assess patients with gynaecological malignancies
2.9.10	Assess patients with sarcoma
2.9.11	Assess primary bone tumours
2.9.12	Assess skeletal metastatic disease
2.9.13	Assess patients with brain malignancy
2.9.14	Assess patients using lymphoscintigraphy
2.9.15	Use SPECT and PET tracers (other than F-18 FDG) to characterise tumours
2.9.16	Explain the use of radiological imaging to assist in the interpretation of oncological nuclear medicine studies

Theme 2.10	Evaluation of Osteoporosis
Learning Objectives	
2.10.1	Describe techniques used to evaluate osteoporosis
2.10.2	Assess quality assurance procedures in bone mineral density (BMD) estimation
2.10.3	Interpret and report lumbar spine BMD scans
2.10.4	Interpret and report proximal femur BMD scans
2.10.5	Assess BMD in appendicular skeleton
2.10.6	Assess total body bone mineral and body composition
2.10.7	Outline absolute fracture risk
Theme 2.11	Pulmonary Nuclear Medicine
Learning Objectives	
2.11.1	Describe the assessment, management, and outcomes of pulmonary embolism (PE) and deep venous thrombosis (DVT)
2.11.2	Assess PE using ventilation and perfusion imaging
2.11.3	Discuss the role of ancillary tests and complementary imaging techniques for PE
2.11.4	Assess patients by quantitation of lung ventilation and perfusion
2.11.5	Assess inflammatory lung disease
DOMAIN 3	**PAEDIATRIC NUCLEAR MEDICINE**
Theme 3.1	Diagnostic and Therapeutic
Learning Objectives	
3.1.1	Describe the basic principles of paediatric nuclear medicine
3.1.2	Assess musculoskeletal disorders
3.1.3	Assess genitourinary disorders
3.1.4	Assess GI disorders
3.1.5	Assess infection and inflammation
3.1.6	Assess thyroid disease
3.1.7	Assess pulmonary disease

3.1.8	Assess malignancy
3.1.9	Assess neurological disease
3.1.10	Assess congenital cardiac disease
DOMAIN 4	**THERAPY**
Theme 4.1	Therapeutic Nuclear Medicine
Learning Objectives	
4.1.1	Treat hyperthyroidism and other benign thyroid disease with I-131
4.1.2	Treat thyroid cancer with I-131
4.1.3	Treat bone pain due to metastatic disease with nuclear medicine therapies
4.1.4	Treat arthritis with radiation synovectomy
4.1.5	Treat haematological malignancy
4.1.6	Treat neuroendocrine tumours
4.1.7	Treat liver malignancy/metastatic disease with intra-arterial therapy

DOMAIN 1	SCIENTIFIC BASIS OF NUCLEAR MEDICINE
Theme 1.1	Basic Sciences
Learning Objective 1.1.1	Describe anatomy and anatomical variants as relevant to nuclear medicine

Knowledge

Cardiac

- identify the cardiac chambers and the great vessels, and explain their anatomical relations in the thorax
- identify the major epicardial arteries and their branches, and explain their relationship to the cardiac chambers and the territories that they perfuse
- list and discuss common variants in cardiac anatomy and coronary artery anatomy
- describe the orientation of the heart in the orthogonal planes and also in the re-oriented short axis, horizontal and vertical long axis planes

Endocrine

- identify anatomy of the thyroid and parathyroid glands and explain their anatomical relations in the neck
- identify the surface anatomy of the thyroid and parathyroid glands
- list and discuss common variants in thyroid and parathyroid anatomy
- identify anatomy of the adrenal glands

GI

- describe anatomy of the oesophagus, stomach, small bowel, and colon
- describe the vascular supply of the GI tract

Genitourinary

- describe the anatomy of the kidneys, ureters, bladder, and genital tracts
- describe the anatomical relations of the kidneys, ureters and bladder in the abdomen and pelvis

Musculoskeletal

- describe the anatomy of the bones and joints of the upper and lower limbs, pelvis, thorax, spine, and skull
- describe the anatomy of skeletal muscle

Neurological

- discuss the anatomy of the brain and spinal cord with particular emphasis on cross-sectional anatomy
- identify the surface markings of the cerebral lobes
- identify the intracerebral structures of the brain in transverse, sagittal, and coronal planes
- identify the cerebral arteries, the territories that they perfuse, and their relations to other cerebral structures
- identify the cerebral veins and sinuses and their relations to other cerebral structures
- identify the cerebral ventricles and their relations to other cerebral structures, including the spinal cord

DOMAIN 1	SCIENTIFIC BASIS OF NUCLEAR MEDICINE
Theme 1.1	Basic Sciences
Learning Objective 1.1.1	Describe anatomy and anatomical variants as relevant to nuclear medicine

Oncological

- describe the anatomy of the brain, head and neck, thorax, abdomen, and pelvis
- identify the location of lymph nodes and describe drainage patterns of the lymphatic system
- identify anatomy of the breast with particular attention to the lymph drainage of the breast

Pulmonary

- identify the lobes and fissures of the lungs and their anatomical relations in the thorax
- identify the bronchopulmonary segments of both lungs
- identify bronchopulmonary segments and their projections in both two dimensional and three dimensional imaging
- describe the blood supply to the lungs.

DOMAIN 1	SCIENTIFIC BASIS OF NUCLEAR MEDICINE
Theme 1.1	Basic Sciences
Learning Objective 1.1.2	Describe pathophysiology as relevant to nuclear medicine

Knowledge

Cardiac

- describe the fundamentals of myocardial contraction
- describe Starling's law and relate this to preload, afterload, myocardial contractility, and mechanisms of cardiac reserve
- describe the determinants of myocardial oxygen consumption and the factors affecting coronary blood flow and flow reserve

Endocrine

- describe the pathophysiology of primary, secondary, and tertiary hyperparathyroidism
- discuss the physiology of the thyroid gland with reference to control by TRH/TSH and thyroid hormone synthesis and storage
- describe thyroid function tests and the results in hyper- and hypothyroidism
- describe iodine handling by the thyroid
- describe the physiological effects of PTH and physiological regulation of PTH secretion
- discuss hormone production and secretion by the adrenal glands

DOMAIN 1	SCIENTIFIC BASIS OF NUCLEAR MEDICINE
Theme 1.1	Basic Sciences
Learning Objective 1.1.2	Describe pathophysiology as relevant to nuclear medicine

GI

- describe the principles of GI motility
- describe the mechanisms of transport and food mixing
- describe the secretory functions of the GI tract
- describe the metabolic functions of the liver, the principles of bile production, and biliary kinetics
- describe the determinants of GI blood flow

Genitourinary

- describe the physiological processes of glomerular filtration, renal blood flow, urine formation, and their control
- describe the tubular processing mechanism of glomerular filtrate
- describe the renal mechanisms involved in blood volume and blood pressure and the effects of diuretics on these mechanisms
- describe the physiological changes induced by acute and chronic renal failure

Musculoskeletal and Evaluation of Osteoporosis

- describe the physiological determinants of muscle contraction
- describe the absorption of calcium and phosphate and their relationship to bone growth and resorption
- describe the relationship between extracellular calcium and phosphate concentrations and bone metabolism
- describe the effects of parathyroid hormone and calcitonin on bone metabolism
- describe the physiological effect of injury to local bone metabolism
- describe the response of muscle to exercise

Infection and Inflammation

- describe the fundamentals of humoral inflammation and cellular inflammation
- describe the general characteristics of neutrophils, lymphocytes, monocytes, and macrophages, and their role in the body's resistance to infection

Neurological

- discuss the physiology of the brain in normal and abnormal states, with particular attention to regional cerebral perfusion
- explain the fundamentals of cerebral perfusion and autoregulation
- describe the relationship between cerebral perfusion and cerebral metabolism in health and disease
- explain the concepts of cerebral blood volume and luxury perfusion
- explain the effect of seizures on cerebral blood flow

DOMAIN 1	SCIENTIFIC BASIS OF NUCLEAR MEDICINE
Theme 1.1	Basic Sciences
Learning Objective 1.1.2	Describe pathophysiology as relevant to nuclear medicine

Oncological

- describe the principles of cellular organisation and growth
- describe the broad mechanisms of carcinogenesis

Pulmonary

- describe the physiologic features of ventilatory function, measurement of ventilatory function, and patterns of abnormal function
- describe the physiologic features of the pulmonary circulation, measurement of pulmonary circulation, and patterns of abnormal function
- describe the physiologic features of gas exchange, measurement of gas exchange, and mechanisms of abnormal function
- describe the relationship between pulmonary blood flow and pulmonary ventilation under normal conditions and in PE
- describe the metabolic functions of the lung and its effects on lung physiology

Radionuclide Therapy

- describe the mechanisms of radiation-induced cell damage
- describe tissue characteristics that modify the response to radiation-induced injury
- describe the general characteristics of the relationship between cell cycle and radiation-induced injury
- describe the effects of toxic doses of radiation on normal organs.

DOMAIN 1	SCIENTIFIC BASIS OF NUCLEAR MEDICINE
Theme 1.1	Basic Sciences
Learning Objective 1.1.3	Describe pathology as relevant to nuclear medicine

Knowledge

Cardiac

- describe the relationship between blood flow in a stenosed coronary artery and myocardial perfusion at rest and during stress
- describe the basic pathogenesis of atherosclerosis with particular reference to coronary artery disease and its consequences
- describe the pathological features of valvular heart disease, cardiomyopathy, endocarditis, and myocarditis
- explain the concepts of reversibly dysfunctional myocardium in coronary artery disease

DOMAIN 1	SCIENTIFIC BASIS OF NUCLEAR MEDICINE
Theme 1.1	Basic Sciences
Learning Objective 1.1.3	Describe pathology as relevant to nuclear medicine

Endocrine

- describe the causes and effects of hyperthyroidism, hyperparathyroidism, and adrenal hypersecretory syndromes
- describe the natural history of thyroid nodules and the relationship of thyroid nodules to thyroid cancer
- describe the interpretation of fine needle aspiration biopsies performed on thyroid nodules

GI

- describe the pathophysiology of GI motility disorders
- describe the pathology of primary and secondary hepatic tumours
- describe the pathophysiology of acute and chronic cholecystitis, biliary dyskinesia, sphincter of Oddi dysfunction, cystic duct syndrome, and post cholecystectomy syndrome
- describe the pathology relating to GI haemorrhage
- describe the pathology of IBD
- describe the pathology of intra-abdominal sepsis

Genitourinary

- describe the pathophysiology of:
  - renovascular hypertension (RVH)
  - types of urinary tract obstruction
  - acute pyelonephritis and renal scarring
  - transplant rejection
  - vesicoureteric reflux
  - renal failure
  - acute tubular necrosis (ATN)
  - acute epididymitis and testicular torsion

Infection and Inflammation

- describe the pathological characteristics of acute and chronic inflammation

Musculoskeletal and Evaluation of Osteoporosis

Metastatic and Infiltrative Disorders:

- describe the routes of tumour spread to bone and osseous response to metastatic tumour
- list the frequency, skeletal distribution, pathological behaviour, and potential imaging appearances of bone metastases from solid and non-solid primary tumours
- describe the risk of metastatic disease of a solitary focus at varying skeletal sites
- list the sites of metastatic disease which carry risk of clinically significant pathological fracture

Primary Bone Tumours:

- describe the pathological features of benign and malignant bone tumours

DOMAIN 1	SCIENTIFIC BASIS OF NUCLEAR MEDICINE
Theme 1.1	Basic Sciences
Learning Objective 1.1.3	Describe pathology as relevant to nuclear medicine

Sports Medicine and Trauma:

- describe the fundamentals of bone response to stress
- describe the pathological features in bone following fracture with particular reference to changes over time

Metabolic Bone Disease:

- describe the pathogenesis and pathological features of osteoporosis, Paget's disease, osteomalacia, hyperparathyroidism, and renal osteodystrophy
- describe the clinicopathological features of regional migratory osteoporosis
- describe the effects on bone metabolism of the various physical and pharmacological treatments that are employed in the treatment and prevention of osteoporosis

Skeletal Infection:

- describe the pathogenesis and pathological features of acute and chronic osteomyelitis (including vertebral osteomyelitis), septic arthritis and discitis

Prosthetic Infection:

- describe the natural history of periprosthetic bone changes in cemented and non-cemented prosthetic joint replacements

Arthritis and Related Conditions:

- list the causes of inflammatory arthritis and describe the basic clinicopathological features of these conditions, including reference to the distribution of joint involvement
- describe the basic clinicopathological features of osteoarthritis and degenerative disease of the spine
- describe the aetiology of osteonecrosis, including radiation osteonecrosis, and bone infarction
- describe the clinicopathological features of complex regional pain syndrome/reflex sympathetic dystrophy (CRPS/RSD)

Neurological

- describe the pathophysiology of atherosclerosis, cerebral ischemia, cerebral infarction, cerebral atrophy, intracranial haemorrhage, intracranial aneurysms, intracranial vascular malformations, cerebral tumours, cerebral vasculitis, drug induced cerebral injury, cerebral HIV/AIDS, and encephalitis
- describe the pathophysiology and classification of seizures
- describe the pathophysiology and classification of dementia
- describe the physiology of CSF production and flow
- describe the pathophysiology of normal pressure hydrocephalus, obstructed hydrocephalus, non-obstructed hydrocephalus, and CSF leaks
- describe the pathophysiology of brain death

Oncological

- describe the pathophysiology of malignant neoplasia
- describe the pathology of:
    - lymphoproliferative disease

DOMAIN 1	SCIENTIFIC BASIS OF NUCLEAR MEDICINE
Theme 1.1	Basic Sciences
Learning Objective 1.1.3	Describe pathology as relevant to nuclear medicine

- breast cancer
- lung cancer
- colorectal cancer
- ovarian cancer
- gastro-oesophageal cancer
- head and neck cancer
- thyroid cancer
- gynaecological malignancies
- brain tumours
- lymphoma
- sarcoma
- neuroendocrine tumours
- breast tumours
- melanoma.

DOMAIN 1	SCIENTIFIC BASIS OF NUCLEAR MEDICINE
Theme 1.2	Principles of Imaging and Nuclear Medicine Scanning
Learning Objective 1.2.1	Apply imaging and scanning techniques
Standard	I

Knowledge	Skills
• describe clinical indications and any contraindications for the particular scan required • discuss where various studies/scanning methods might be the preferable investigation as well as the limitations of these studies • discuss the agents, volumes, and activities to be used, taking into account the clinical case involved, the purpose of the investigation being undertaken, the physical properties of the agent, and physiology • describe conditions where there needs to be an alteration to standard protocols • describe appropriate preparation for the various studies/scanning methods with particular reference to any medications that should be withheld • discuss the normal ranges and the appearances of a normal study/scan • describe abnormalities that may occur, their appearances and diseases that may be responsible • outline relevant laboratory and imaging investigations that may assist in interpretation of the global picture for reporting and discussing results with the referring clinician • describe the underlying anatomy, physiology, and pathology of conditions commonly causing abnormalities and why these abnormalities result in the various scan patterns.	• analyse clinical cases to identify indications and contraindications • evaluate limitations of scans for clinical cases • determine the appropriate dosage or activity of the agent(s) to be used, taking into account the physical properties and biodistribution of the agent(s) • communicate camera imaging and analysis parameters for the procedure to technological staff • explain patient preparation requirements to nursing staff • ensure that patient is optimally prepared for the procedure • explain procedures, protocols, risks, and benefits to patients undergoing scans • recognise and interpret a normal scan • recognise and interpret the characteristics of an abnormal scan • confirm the interpretation and reporting of the scan • interpret and report on the scan to referring practitioners, both orally and in writing • discuss the use and limitations of the scan technique and interpretation criteria used • teach medical students, nuclear medicine technologists, and junior medical staff about the use and limitations of the scanning technique in the diagnosis and management of specific clinical problems.

DOMAIN 1	SCIENTIFIC BASIS OF NUCLEAR MEDICINE
Theme 1.3	Professional Practice
Learning Objective 1.3.1	Describe the safety and quality requirements of nuclear medicine practice
Links	ANZAPNM Basic Sciences in Nuclear Medicine Curriculum

Knowledge	Skills

• outline the basic principles of radioactive decay, nuclear reactions and production of radionuclides, detection and measurement of ionising radiation
• discuss the effects of ionising radiation on humans
• describe the legislative control of radiation in Australia and New Zealand
• describe the principles and procedures of radiation protection as applied to nuclear medicine, including the as low as reasonably achievable (ALARA) principle
• describe the principles of operation of SPECT, PET, CT and hybrid SPECT/CT and PET/CT cameras, including:
  • performance characteristics, and differences between cameras
  • quality control
  • equipment specification and selection
  • computer acquisition
  • image processing and display
• describe recent developments in nuclear medicine instrumentation and explain how these may have an impact on the future practice of the specialty
• outline the principles of technetium chemistry, including:
  • metal complexes and the technetium generator
  • chemical analysis procedures of technetium radiopharmaceuticals
  • the range of technetium cold-kits in current use and radiochemical tests
• describe the use of non-technetium radiopharmaceuticals, including tumour diagnostic and therapy agents and radiolabelled cells
• discuss recent developments and future trends in diagnostic and therapeutic radiopharmaceuticals.
	• explain and apply principles of radiation safety to:
	  • adult patients, including pregnant or breastfeeding patients
	  • paediatric patients
	  • practice staff
	• advise referring doctors, medical students, nuclear medicine technologists, and junior medical staff about the principles of:
	  • radiation safety, including legislative requirements
	  • operation of SPECT, PET, CT, and hybrid cameras
	  • principles of radiopharmaceutical chemistry
	  • recent developments and trends in nuclear medicine instrumentation and diagnostic and therapeutic radiopharmaceuticals.

Teaching and Learning Resources

- ANZAPNM Basic Sciences in Nuclear Medicine Course Curriculum – located on trainee's portal at: www.anzapnm.org.au/moodle.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.1	Cardiovascular Nuclear Medicine
Learning Objective 2.1.1	Supervise and interpret resting and exercise ECGs
Standard	I

Knowledge	Skills

• identify characteristics of abnormal ECGs for common abnormalities, including:
  • heart block
  • bundle branch block
  • atrial arrhythmias
  • ventricular arrhythmias
  • myocardial infarction
  • myocardial ischaemia
  • left ventricular hypertrophy
  • pericarditis and left ventricular aneurysm
  • Wolff-Parkinson-White syndrome
  • QT interval abnormalities
  • changes of acute ischaemia at rest
• recognise and interpret characteristics of abnormal ECGs for common abnormalities.
	• supervise and perform exercise ECG studies using Bruce or other standard protocols
	• interpret exercise ECG studies and apply criteria for positive, negative, non-diagnostic, and uninterpretable exercise ECGs
	• assess pre-test probabilities for common patient groups suspected of coronary artery disease
	• prepare skin and place ECG electrodes correctly
	• terminate exercise tests at appropriate endpoint
	• evaluate clinical cases to determine likelihood of false positive and false negative exercise tests
	• manage arrhythmias and other cardiac events that may be caused by exercise tests
	• perform cardiopulmonary resuscitation if required
	• discuss limitations and requirements of common treadmill and cycle ergometer protocols, handgrip isometric exercise, atrial pacing, and cold pressor testing with nuclear medicine specialists and referring cardiologists.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.1	Cardiovascular Nuclear Medicine
Learning Objective 2.1.2	Supervise and interpret stress testing using pharmacological agents
Standard	I

Knowledge	Skills

• explain the role of pharmacological stress testing in the evaluation of coronary artery disease
• identify when pharmacological agents are indicated and contraindicated
• discuss limitations of pharmacological stress testing and specific preparations for the study
• recognise new pharmacological agents, such as adenosine 2A agonists.
	• supervise and perform stress testing using pharmacological agents and treat any side effects and/or complications that may occur, and perform cardiopulmonary resuscitation if required
	• interpret ECG studies done in conjunction with pharmacological stress testing and apply criteria for positive, negative, non-diagnostic, and uninterpretable ECGs
	• prepare skin and place ECG electrodes correctly
	• evaluate clinical cases to determine likelihood of false positive and false negative pharmacological stress tests
	• determine the appropriate pharmacological agents to be used, taking into account:
	  • clinical case
	  • purpose of investigation
	  • mode and duration of action, haemodynamic response, and infusion protocols of dipyridamole, dobutamine plus atropine, and adenosine.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.1	Cardiovascular Nuclear Medicine
Learning Objective 2.1.3	Assess coronary artery disease using SPECT radiopharmaceuticals
Standard	I

Knowledge	Skills

• describe the cardiac handling of Tc-99m-labelled tracers and how it affects imaging
• discuss the literature supporting the use of Tc-99m-labelled tracers and Tl-201 in the diagnosis of coronary artery disease and in risk stratification
• recognise the advantages and disadvantages of Tc-99m labelled tracers compared with Tl-201
• recognise the radiation exposure to the patient from Tc-99m-labelled tracers and Tl-201
• describe the use of Tl-201 in the diagnosis of coronary artery disease and myocardial viability
• discuss the cardiac handling of Tl-201 and how it differs from the Tc-99m based cardiac tracers
• recognise the different protocols for Tl-201, including delayed imaging and re-injection protocols
• describe CT-based attenuation correction (CTAC) and scatter correction algorithms and the suitability, quality control, and limitations of these techniques
• interpret left ventricle (LV) and right ventricle (RV) function both regionally and globally with rest and exercise.
	• supervise and interpret myocardial perfusion scans using Tc-99m-labelled tracers and/or Tl-201 for:
	  • diagnostic evaluation of possible coronary artery disease
	  • prognostic evaluation of the post myocardial infarction patient
	  • evaluation of efficacy of revascularisation procedures
	  • preoperative risk stratification of patients undergoing non-cardiac surgery
	  • detection of myocardial viability
	• assess the use and limitations of:
	  • scatter and attenuation correction techniques
	  • ECG gating
	  • quantitative methods supporting interpretation and reporting of myocardial perfusion imaging scans.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.1	Cardiovascular Nuclear Medicine
Learning Objective 2.1.4	Assess ventricular function using radionuclide ventriculography
Standard	I

Knowledge	Skills

• identify normal and abnormal regional wall motion
• define the methods of ECG gating, their strengths and pitfalls
• differentiate abnormality in context of patient, e.g. left bundle branch block (LBBB) and septal dyskinesis
• identify the significance of a change in ejection fraction (EF), i.e. change in loading conditions between studies leading to a change in EF within normal range vs. pathological fall in EF, development of apical lag, and LV dilation
• recognise the significance of the EF in the context of regurgitant valvular disease
• describe SPECT gated cardiac blood pool scans (GCBPS).
	• supervise and interpret radionuclide ventriculography in the investigation of the following:
	  • regional wall motion
	  • stroke volume
	  • LV EF, at rest and with exercise
	  • phase analysis
	  • amplitude analysis
	  • aortic regurgitation and other valvular heart disease
	  • diastolic dysfunction
	  • RV wall motion
	  • ventricular failure
	  • cardiomyopathy
	  • chemotherapy induced cardiotoxicity
	  • coronary artery disease and myocardial infarction
	  • congenital heart disease
	• determine the appropriate methods of Tc-99m labelling of red blood cells
	• identify limitations and sources of error with radionuclide ventriculography.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.1	Cardiovascular Nuclear Medicine
Learning Objective 2.1.5	Assess congenital heart disease using radiolabelled shunt studies
Standard	A

Knowledge	Skills

• assess RV and LV systolic function at rest and peak stress in patients with congenital heart disease. In particular:
  • tetralogy of Fallot
  • transposition of the great arteries
  • prior to the commencement of heart failure therapy, implantable cardioverter-defibrillator (ICD) insertion, valve surgery, and cardiac transplantation.
	• supervise and interpret radiolabelled shunt studies for congenital heart disease in conditions such as:
	  • atrial septal defect (ASD)
	  • ventricular septal defect (VSD)
	  • patent ductus arteriosus (PDA)
	  • tetralogy of Fallot
	  • Eisenmenger's syndrome
	• determine and apply techniques for investigating and quantifying left-to-right and right-to-left shunts.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.1	Cardiovascular Nuclear Medicine
Learning Objective 2.1.6	Perform I-123 MIBG adrenergic cardiac imaging studies
Standard	I

Knowledge	Skills

• describe the physiology of I-123 MIBG and the normal distribution of the tracer, and its usual distribution in pathological conditions, including:
  • neuroendocrine tumours
  • cardiac failure
  • Parkinson's type syndromes.
	• supervise and interpret I-123 MIBG cardiac imaging studies
	• identify potential clinical indications for I-123 MIBG cardiac studies
	• determine optimal imaging techniques for performance of I-123 MIBG cardiac studies
	• evaluate any technical limitations which may affect the interpretation of I-123 MIBG cardiac imaging studies.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.1	Cardiovascular Nuclear Medicine
Learning Objective 2.1.7	Discuss the role of complementary imaging techniques for cardiac disease
Standard	WI

Knowledge	Skills
• explain the complimentary role of stress echocardiography and cardiac CT in the assessment of coronary artery disease • outline the evidence base in literature for relative strengths and limitations of myocardial perfusion scintigraphy, stress echocardiography, and cardiac CT.	• discuss with referring clinicians the accuracy and limitations of echocardiography, stress ECG, echocardiography, cardiac CT/CTCA, cardiac MRI scans, and coronary angiography in the detection of coronary artery disease, the risk stratification of post infarction patients and the detection of viable myocardium.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.1	Cardiovascular Nuclear Medicine
Learning Objective 2.1.8	Discuss the role of CTCA in the management of coronary artery disease
Standard	WI

Knowledge	Skills
• explain the principles of CT acquisition, image visualisation, and interpretation for the performance of attenuation correction, calcium scoring, and CT coronary angiography. This can be with SPECT or on standalone cardiac CT • describe coronary anatomy in interpreting cardiac CT • identify the appropriate indications for cardiac CT • identify contraindications and limitations of cardiac CT.	• observe the performance of CTCA studies • observe administration of beta-blocker and determination of the suitability of administration of contrast to the patient • identify each coronary artery and recognise the difference between soft and hard plaque • recognise the strengths and limitations of cardiac CTCA.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.1	Cardiovascular Nuclear Medicine
Learning Objective 2.1.9	Assess coronary artery disease using PET
Standard	A

Knowledge	Skills
• discuss the use and limitations of F-18 FDG cardiac imaging in the identification of damaged and viable myocardium • explain the principles and practice for the preparation of patients for myocardial viability studies using F-18 FDG • identify other perfusion PET tracer imaging techniques such as Rb-82 or N-13 ammonia • describe how F-18 FDG can be used for assessment of coronary artery disease, i.e. for imaging ischaemia, as opposed to viability.	• supervise and interpret cardiac PET images using F-18 FDG and be aware of the strengths and limitations of the procedure, requirements for patients preparation, and technical limitations of the study • advise referring clinicians on the relative strengths and limitations of F-18 FDG imaging, Tl-201 and Tc-99m sestamibi imaging in the assessment of myocardial viability and blood flow • supervise studies to achieve a hyperinsulinaemic euglycaemic state to optimise F-18 FDG uptake in myocardium • recognise the typical pattern of metabolism in normal, viable, and infarcted myocardium • apply ECG-gated techniques to assess regional wall abnormalities and global LV systolic function.

Theme 2.1 Teaching and Learning Resources

- *Nuclear Medicine in Clinical Diagnosis and Treatment*, Ell PJ and Gambhir SS (Eds), 3rd Edition, 2004, Churchill Livingston, Edinburgh
- Cardiac Society of Australia and New Zealand (CSANZ), CSANZ Safety and Performance Guidelines for Clinical Exercise Stress Testing, 2008. Available from: http://www.csanz.edu.au
- CSANZ/ANZAPNM Safety and Performance Guidelines for Pharmacologic Stress Testing in Conjunction with Clinical Cardiac Imaging Procedures, 2009. Available from: http://www.csanz.edu.au
- European Association of Nuclear Medicine (EANM): EANM procedure guidelines for cardiac function: http://www.eanm.org/scientific_info/guidelines/gl_cardio_ranuc_img_card_funct.pdf
- EANM procedure guidelines for myocardial perfusion imaging: http://www.eanm.org/scientific_info/guidelines/gl_cardio_myocard_perf.pdf
- Society of Nuclear Medicine (SNM): SNM procedure guidelines for myocardial perfusion scintigraphy http://interactive.snm.org/docs/155.pdf
- Note that training in CTCA is overseen by the Conjoint Committee for the Recognition of Training in CT Coronary Angiography (the Conjoint Committee), comprising representatives of the ANZAPNM, CSANZ and the RANZCR. Nuclear medicine trainees must be well informed of CTCA as a complementary technology. Trainees, particularly those with a cardiac interest, are strongly encouraged to complete formal CTCA training. This includes course work (available in Australia) and live cases. Such training can be performed during core nuclear medicine training. Information on the training requirements for credentialling for CTCA can be found on the Conjoint Committee's website: www.anzctca.org

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.2	Endocrine Nuclear Medicine
Learning Objective 2.2.1	Assess thyrotoxicosis
Standard	I

Knowledge	Skills
• describe the causes of thyrotoxicosis and their management • discuss the role of Tc-99m pertechnetate in general thyroid scintigraphy, its radiochemistry, and its advantages and disadvantages compared to radioactive iodine • outline the preparation of the patient prior to scanning • describe methods for quantitation of thyroid uptake and the advantages and disadvantages of each approach.	• discuss the use and limitations of thyroid scans and provocative testing in patients with thyrotoxicosis, with nuclear medicine specialists and referring clinicians • supervise and interpret thyroid scans for patients with thyrotoxicosis • discuss thyroid physiology in the normal and pathologic state with respect to scintigraphic appearances • identify patterns of thyroid uptake depending on the aetiology of thyrotoxicosis • recognise the appearance of normal variants, aberrant thyroid anatomy and artefacts.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.2	Endocrine Nuclear Medicine
Learning Objective 2.2.2	Assess nodular thyroid disease
Standard	I

Knowledge	Skills
• describe the histopathological types of thyroid nodules and their appearance on thyroid scintigraphy • discuss the significance of a 'cold', 'warm' and 'hot' nodule, with particular attention to the likelihood of malignancy • recognise and discuss the limited indications for Tc-99m pertechnetate thyroid scintigraphy in the workup of a thyroid nodule prior to biopsy • recognise the significance of nodular uptake of Tc-99m sestamibi, thallium, and F18-FDG • discuss the role of I-131 and F-18 FDG PET in patients with thyroid cancer (see also learning objectives 2.9.5 and 4.1.2).	• discuss the indications and limitations of thyroid scans in patients with thyroid nodules with nuclear medicine specialists and referring clinicians • mark thyroid nodule(s) so that the nodule(s) can be clearly identified and related to radiological findings by referring clinicians • recognise the indications and limitations of thyroid ultrasound and fine needle aspiration biopsy in the management of thyroid nodules.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.2	Endocrine Nuclear Medicine
Learning Objective 2.2.3	Assess hyperparathyroidism
Standard	I

Knowledge	Skills

• discuss the embryology of the thyroid and parathyroid glands and recognise the impact on gland localisation
• describe the factors influencing parathyroid gland uptake of Tc-99m agents such as Tc-99m sestamibi
• discuss the sensitivity and specificity of Tc-99m sestamibi imaging compared to ultrasound
• discuss localisation studies in the era of minimally invasive surgery
• describe imaging protocols with particular attention to:
  • choice of collimator
  • oblique imaging
  • use of SPECT and SPECT/CT
  • imaging of the mediastinum
  • delayed imaging, image subtraction techniques
  • correlative thyroid scintigraphy.
	• supervise and interpret sestamibi parathyroid scans for hyperparathyroidism
	• recognise the typical patterns of parathyroid adenomas/hyperplasia in the neck and in ectopic locations
	• distinguish parathyroid abnormalities from thyroid abnormalities.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.2	Endocrine Nuclear Medicine
Learning Objective 2.2.4	Assess adrenal hypersecretory syndromes using radiolabelled tracers
Standard	I

Knowledge	Skills
• discuss the common finding of an adrenal mass on CT, an incidentaloma, and their clinical significance • discuss the usual diagnostic work-up of an adrenal lesion • discuss the usual diagnostic work-up of hypercortisolism • describe the instances when radiolabelled cholesterol imaging may be useful • discuss how SPECT and SPECT/CT imaging can enhance diagnostic confidence and accuracy in adrenal imaging.	• supervise and interpret adrenal scans, using MIBG, labelled with I-123 or I-131 • supervise and interpret adrenal scans, using radiolabelled cholesterol • recognise the strengths and limitations of adrenal imaging and explain the patient preparation required.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.2	Endocrine Nuclear Medicine
Learning Objective 2.2.5	Discuss the role of complementary imaging techniques for endocrine disease
Standard	WI

Knowledge	Skills
• interpret the results of ultrasound examinations performed on patients for the assessment of thyroid and parathyroid disease • discuss the limitations of ultrasound examinations performed on patients for the assessment of thyroid and parathyroid disease.	• advise referring practitioners of the relative strengths and limitations of nuclear medicine and ultrasound for the assessment of thyroid and parathyroid disease.

Theme 2.2 Teaching and Learning Resources

- *Nuclear Medicine in Clinical Diagnosis and Treatment*, Ell PJ and Gambhir SS (Eds), 3rd Edition, 2004, Churchill Livingston, Edinburgh
- SNM procedure guidelines for thyroid scintigraphy: http://interactive.snm.org/docs/pg_ch05_0403.pdf
- SNM procedure guidelines for imaging differentiated thyroid cancer: http://interactive.snm.org/docs/Scintigraphy%20for%20Differentiated%20Thyroid%20Cancer%20V3%200%20%289-25-06%29.pdf
- EANM Guidelines for parathyroid imaging: http://www.eanm.org/scientific_info/guidelines/gl_parathyroid_2009.pdf
- EANM Guidelines for MIBG imaging: http://www.eanm.org/scientific_info/guidelines/gl_onco_mibg.pdf

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.3	GI Nuclear Medicine
Learning Objective 2.3.1	Assess GI motility disorders
Standard	I

Knowledge	Skills
• describe the pathophysiology of the problems that can occur in the GI tract concerning transit, including scleroderma, diabetes, and severe constipation • describe the patient preparation requirement for oesophageal transit studies, gastric emptying studies, small bowel transit studies, and colonic transit studies • discuss the need for fasting and medication cessation in some studies • discuss the impact of medications and smoking on GI motility • determine the correct study for the indication and correct type of meal/isotope to be administered • discuss the impact of scatter if a dual isotope gastric emptying study is performed • describe the methodology of imaging different types of GI transit, including that of the oesophagus, stomach, and colon • describe options for computer analysis and quantitation and be familiar with displays for study reporting • describe technical limitations that can occur with processing and quantitation of GI motility studies • identify the criteria for positivity and negativity in the diagnosis of GI dysmotility.	• supervise and interpret oesophageal transit studies • supervise and interpret gastric emptying studies • supervise and interpret small bowel transit studies • supervise and interpret colonic transit studies • recognise the patterns of abnormality suggestive of GI dysmotility in the oesophagus, stomach, and colon • recognise whether alternate or additional imaging is required.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.3	GI Nuclear Medicine
Learning Objective 2.3.2	Assess hepatic lesions
Standard	I

Knowledge	Skills

• describe the pathologic features of cavernous haemangiomas, focal nodular hyperplasia, and other hepatic lesions
• describe the typical patterns of uptake of Tc-99m RBCs, Tc-99m sulphur colloid, and Tc-99m DISIDA in different hepatic lesions
• recognise limitations of Tc-99m RBC scans in clinical practice
• discuss the options for labelling RBCs and technical problems that may arise
• discuss the value of early imaging, and the use of SPECT and/or SPECT/CT in the evaluation of hepatic lesions
• describe factors that may degrade the study quality
• recognise the normal hepatic vascular anatomy
• describe the physiological basis of Tc-99m sulphur colloid liver-spleen scans, their modern day utility, and the pathology responsible for the classic findings in:
  • chronic liver disease
  • focal nodular hyperplasia
  • hepatic adenoma
  • portal hypertension
  • Budd-Chiari syndrome
  • portal vein thrombosis
  • splenomegaly.
	• advise referring clinicians the appropriate study to perform in the evaluation of hepatic lesions in specific patients
	• supervise and interpret Tc-99m RBC liver scans in the evaluation of hepatic lesions
	• supervise and interpret Tc-99m sulphur colloid scans in the evaluation of hepatic lesions
	• supervise and interpret Tc-99m DISIDA scans in the evaluation of hepatic lesions
	• supervise and interpret Tc-99m sulphur colloid scans in the evaluation of chronic liver disease, portal hypertension, Budd-Chiari syndrome and portal vein thrombosis
	• recognise normal appearances as well as the typical patterns of abnormality in conditions such as:
	  • cavernous haemangioma
	  • focal nodular hyperplasia
	  • hepatic adenoma.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.3	GI Nuclear Medicine
Learning Objective 2.3.3	Assess gallbladder and biliary function using hepatobiliary scans
Standard	I

Knowledge	Skills

• discuss the agents most commonly used, dose, pharmacokinetics and pharmacodynamics, biodistribution in normal and abnormal liver function, and how the agent(s)/studies are useful in investigating acute cholecystitis, chronic cholecystitis, post cholecystectomy pain and bile leaks
• recognise the effects of different administration protocols on the resultant hepatobiliary scans, including how cholecystokinin (CCK) infusion rates will effect gall bladder EFs
• discuss options to induce gallbladder contraction with Sincalide (CCK), and fatty meals, including the advantages and disadvantages of each
• discuss the options for dose, rate and mode of administration, contraindications and complications of Sincalide (CCK) infusions
• discuss the role of morphine in hepatobiliary studies, including the indication for use, dose, patient preparation, side effects, complications, and contraindications
• recognise variations to the standard imaging protocols which may be needed for diagnosis of acute and chronic cholecystitis, biliary leaks, post-cholecystectomy pain, common bile duct obstruction, or obstruction of major hepatic ducts
• describe the utility of oblique and lateral planar imaging as well as the use of SPECT/CT for these investigations
• describe technical issues that can arise during processing that may affect the accuracy of quantitative results
• explain the accuracy of these tests in diagnosis of each of the above conditions together with positive predictive value (PPV) and negative predictive value (NPV)
• outline other investigations useful in the diagnosis of each condition and the typical findings in these
	• advise referring clinicians the appropriate imaging study to perform in patients with various clinical presentations of upper abdominal pain to evaluate gallbladder function
	• supervise and interpret hepatobiliary scans for the assessment of:
	  • acute cholecystitis
	  • chronic cholecystitis
	  • post cholecystectomy pain
	  • bile leaks
	• determine the need for pharmacological intervention in these hepatobiliary scans
	• recognise normal and abnormal scan appearances in:
	  • acute cholecystitis
	  • chronic cholecystitis
	  • post cholecystectomy pain
	  • bile leaks
	  • biliary dyskinesia/sphincter of Oddi dysfunction
	  • common bile duct obstruction
	  • obstruction of major hepatic ducts
	• advise referring clinicians on the significance of suboptimal gallbladder EFs in patients with suspected gallbladder disease
	• implement variations to the standard imaging protocols which may be needed for diagnosis of acute and chronic cholecystitis, biliary leaks, post-cholecystectomy pain, common bile duct obstruction, or obstruction of major hepatic ducts.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.3	GI Nuclear Medicine
Learning Objective 2.3.3	Assess gallbladder and biliary function using hepatobiliary scans

• discuss typical findings in acute cholecystitis, chronic cholecystitis, post cholecystectomy pain and bile leaks
• discuss the typical scan findings and limitations of these studies in the investigation of abnormal biliary kinetics such as:
  • common bile duct obstruction
  • sphincter of Oddi dysfunction
  • obstruction of major hepatic ducts
• describe changes seen in severe liver disease and how image quality may be affected
• discuss the appropriate protocols and diagnostic accuracy of these tests in diagnosis of post-cholecystectomy pain.	

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.3	GI Nuclear Medicine
Learning Objective 2.3.4	Assess GI haemorrhage
Standard	I

Knowledge	Skills
• list and discuss the common pathologies responsible for patients presenting with GI haemorrhage • describe typical scan findings for active bleeding from the stomach/duodenum, small bowel, colon, and rectosigmoid region • discuss the bleeding rates required to be detected on the scan • describe the cell labelling techniques required, and the time factors involved, in preparation and imaging, as well as typical labelling quality with each technique • discuss other investigations which may be used in the diagnosis and treatment of active GI bleeding, and their relative advantages and disadvantages • discuss protocol options, including dynamic vs. static acquisitions and the use of SPECT/CT • describe monitoring and resuscitation procedures that may be necessary in the management of patients while they are in the nuclear medicine practice.	• supervise and interpret labelled RBC studies to assess GI bleeding • recognise normal and abnormal findings as well as typical findings in upper and lower GI bleeding • determine appropriate clinical monitoring procedures in patients undergoing scanning and initiate suitable resuscitation if needed.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.3	GI Nuclear Medicine
Learning Objective 2.3.5	Assess inflammatory bowel disease (IBD) and intra-abdominal sepsis
Standard	I

Knowledge	Skills
• describe the different preparations/agents and isotopes available for leucocyte labelling and how they differ according to their biodistribution and degradation • discuss how this relates to the imaging of GI sepsis • discuss the classification of IBD • describe the pathology in these different conditions and how this may influence interpretation of scan findings • discuss limitations and contraindications of radiolabelled white cell scans for clinical cases as well as the PPV and NPV for this imaging modality • describe the different imaging protocols for different agents • outline the method(s) of cell preparation and administration • describe cell distribution in a normal white cell scan at each different time interval • discuss the advantages and disadvantages of labelled leucocytes compared with Ga-67 for the assessment of intra-abdominal sepsis • discuss how SPECT and SPECT/CT imaging can enhance diagnostic confidence and accuracy in IBD imaging.	• supervise and interpret labelled leucocyte scans to assess for IBD and intra-abdominal sepsis • recognise normal and abnormal findings as well as typical findings in IBD • advise referring clinicians the strengths and limitations of labelled leucocyte studies compared with other diagnostic studies, including Ga-67, in patients with IBD and/or intra-abdominal sepsis.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.3	GI Nuclear Medicine
Learning Objective 2.3.6	Assess abnormal splenic function using Tc-99m labelled tracers
Standard	A

Knowledge	Skills
• describe the clinical conditions in which these scans may be of benefit • describe how these scans supplement or may be advantageous over other imaging techniques • describe the specific agent preparation techniques required for this procedure, and technical complications that can occur • discuss when SPECT/CT may be appropriate.	• supervise and interpret a normal Tc-99m labelled heat damaged RBC scan.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.3	GI Nuclear Medicine
Learning Objective 2.3.7	Assess hepatic artery catheters and peritoneal-venous shunts using Tc-99m labelled tracers
Standard	A

Knowledge	Skills
• describe the options for performing shunt studies, including choice of radiopharmaceuticals, injection techniques and imaging protocols, including the use of planar vs. SPECT or SPECT/CT • describe the typical findings that are seen with correct catheter placement, a misplaced catheter and a blocked catheter for both hepatic artery catheters and peritoneal-venous shunts • describe the role of Tc-99m hepatic arterial perfusion scintigraphy in the treatment of malignant liver masses.	• supervise, perform and interpret Tc-99m macroaggregated albumen (MAA) shunt studies • advise referring clinicians the strengths and limitations of the study.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.3	GI Nuclear Medicine
Learning Objective 2.3.8	Describe the use of salivary and lacrimal gland imaging
Standard	A

Knowledge	Skills
• discuss the clinical use of scintigraphic techniques in the assessment of salivary gland dysfunction and parotid gland tumours • discuss the technique and clinical use of dacryoscintigraphy in the assessment of tear duct blockage.	• supervise and interpret the results of salivary gland scintigraphy with use of pertechnetate and lemon juice • supervise and interpret the results of dacryoscintigraphy • advise referring clinicians on the use of salivary and lacrimal gland imaging.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.3	GI Nuclear Medicine
Learning Objective 2.3.9	Assess GI disease using complementary GI imaging techniques
Standard	WI

Knowledge	Skills
• describe the role of endoscopy, ultrasound, CT, and MRI investigations in the assessment of GI disease • describe the role of ultrasound and CT in the assessment of hepatobiliary disease • discuss the accuracy of abdominal angiography in the localisation of GI haemorrhage compared with scintigraphy • obtain a thorough knowledge of cross-sectional anatomy relevant to the abdomen, liver, and biliary system.	• interpret the results of abdominal CT and ultrasound examinations in the assessment of GI and hepatobiliary disease • interpret the results of endoscopic retrograde cholangiopancreatography (ERCP) in the assessment of biliary disease • advise referring practitioners of the appropriateness of complementary investigations in the investigation of patients with GI disease.

Theme 2.3 Teaching and Learning Resources
• *Nuclear Medicine in Clinical Diagnosis and Treatment*, Ell PJ and Gambhir SS (Eds), 3rd Edition, 2004, Churchill Livingston, Edinburgh • Algeo JH, Powell M, Coucaud J. Leveen shunt visualisation without function using Technetium-99m macroaggregated albumin. *Clin Nuc Med* 1987:12:741-743. • SNM procedure guidelines for hepatobiliary scintigraphy: http://interactive.snm.org/docs/Hepatobiliary_Scintigraphy_V4.0.pdf • SNM procedure guidelines for gastric emptying: http://interactive.snm.org/docs/Guideline%20for%20Adult%20Gastric%20Emptying.pdf • SNM procedure guidelines for hepatic and splenic imaging: http://interactive.snm.org/docs/pg_ch10_0403.pdf • SNM procedure guidelines for GI bleeding/Meckel's diverticulum: http://interactive.snm.org/docs/pg_ch09_0403.pdf

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.4	Genitourinary Nuclear Medicine
Learning Objective 2.4.1	Assess urinary tract obstruction using renal scans
Standard	I

Knowledge	Skills
• identify which radiopharmaceuticals can be used when performing renal scintigraphy for the diagnosis of obstruction, and their relative advantages and disadvantages in this setting • discuss the various protocols in use for diuretic renography, including the dose of the diuretic and the timing of the administration of the diuretic in relation to the timing of commencement of scintigraphy • describe what scan findings are features of obstruction • describe the options to quantitate the study and potential technical pitfalls that can occur.	• assess patients with suspected or known obstruction to determine the appropriate nuclear medicine renal study to be employed • supervise and interpret renal scans to assess for outflow obstruction • determine the indications for diuretic administration and the optimal dose and timing in various clinical circumstances.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.4	Genitourinary Nuclear Medicine
Learning Objective 2.4.2	Assess renal tract infection
Standard	I

Knowledge	Skills
• identify the radiopharmaceuticals used for renal cortical imaging and their various advantages and limitations in this setting • describe the imaging protocols used when performing renal cortical imaging	• supervise and interpret a renal scan to assess for renal tract infection • advise the referring clinician on the appropriate timing of follow-up scans to assess for resolution of renal tract infection.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.4	Genitourinary Nuclear Medicine
Learning Objective 2.4.2	Assess renal tract infection

• explain the importance of the timing of the study in relation to when the urinary tract infection occurred • describe the scan appearances which may differentiate acute infective changes from those of chronic scarring • discuss the imaging options for renal cortical scintigraphy, including the use of pinhole imaging, SPECT, and SPECT/CT • explain the correlation of these scans with radiological techniques • describe the options to quantitate the study and potential technical pitfalls that can occur.	

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.4	Genitourinary Nuclear Medicine
Learning Objective 2.4.3	Assess renovascular hypertension
Standard	I

Knowledge	Skills
• identify which radiopharmaceuticals can be used to perform renal scintigraphy for renovascular hypertension and their advantages and limitations in this setting • identify which angiotensin converting enzyme (ACE) inhibitor to administer prior to the radiopharmaceutical, the dose and the timing between administration of ACE inhibitors and commencement of scintigraphy • discuss the appropriate patient preparation for patients undergoing renal scintigraphy for renovascular hypertension • explain what scan findings are characteristic of functionally significant renal artery stenosis • describe the options to quantitate the study and potential technical pitfalls that can occur.	• supervise and interpret renal scans for renovascular hypertension • administer ACE inhibitors at the appropriate time to maximise the diagnostic accuracy of the study • consider the influence of medications, blood pressure posture, and exercise on renal scans in the detection of renovascular hypertension, and prepare the patient to ensure that the study is performed optimally.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.4	Genitourinary Nuclear Medicine
Learning Objective 2.4.4	Assess a renal transplant patient
Standard	A

Knowledge	Skills
• describe the medical and surgical complications of renal transplantation • describe the scan appearances that are observed in renal transplant kidneys • identify the radiopharmaceuticals that can be used to perform scintigraphy in patients with renal transplants and their advantages and limitations in this setting • explain the modifications of the examination required depending on the clinical setting, including the use of diuretics, ACE inhibitors, and post void imaging • describe the options to quantitate the study and potential technical pitfalls that can occur.	• supervise and interpret renal scans in patients with renal transplants.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.4	Genitourinary Nuclear Medicine
Learning Objective 2.4.5	Assess renal failure
Standard	I

Knowledge	Skills
• identify the radiopharmaceuticals that can be used to perform scintigraphy in patients with renal failure and their advantages and limitations in this setting • describe the different scintigraphic patterns seen in renal failure when different radiopharmaceuticals are used • describe the options to quantitate the study and potential technical pitfalls that can occur.	• supervise and interpret renal scans in patients with renal failure.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.4	Genitourinary Nuclear Medicine
Learning Objective 2.4.6	Discuss the role of complementary imaging techniques for genitourinary disease
Standard	WI

Knowledge	Skills
• discuss the role of other imaging modalities in the assessment of patients with various renal pathologies.	• interpret the results of complementary imaging performed for the assessment of renal disease • advise referring clinicians of the appropriateness, strengths, and limitations of complementary investigations in the investigation of patients with renal disease.

Theme 2.4 Teaching and Learning Resources

- *Nuclear Medicine in Clinical Diagnosis and Treatment*, Ell PJ and Gambhir SS (Eds), 3rd Edition, 2004, Churchill Livingston, Edinburgh
- Rossleigh MA, Farnsworth RH, Leighton DM et al. Technetium-99m Dimercaptosuccinic acid scintigraphy studies of renal cortical scarring and renal length. *J Nuc Med* 1998; 39:1280-1285.
- Dubovsky EV, Russell CD, Bischof-Delaloye A. et al. Report of the Radionuclides in Nephrourology Committee for the Evaluation of Transplanted Kidney (Review of Techniques) *Seminars in Nuclear Medicine* 1999; 29;175-188.
- SNM procedure guidelines for renovascular hypertension: http://interactive.snm.org/docs/pg_ch16_0403.pdf

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.5	Infection and Inflammation Nuclear Medicine
Learning Objective 2.5.1	Assess infection and inflammation using nuclear medicine techniques
Standard	I

Knowledge	Skills

• describe the range of differential diagnoses in a patient presenting with pyrexia of unknown origin (PUO)
• define the role of gallium, radiolabelled white cells, anti-granulocyte antibodies, and F-18 FDG PET
• describe the differing properties, roles, advantages, and disadvantages of different white cell labelling methods and recognise the normal pattern of physiological distribution
• recognise correlative CT findings associated with an inflammatory process to enhance interpretation of SPECT/CT or PET/CT
• discuss how SPECT and SPECT/CT imaging can enhance diagnostic confidence and accuracy in infection imaging
• define the advantages and disadvantages of gallium imaging in an immunocompromised patient
• discuss alternative infection imaging techniques, with particular reference to an immunocompromised patient
• recognise potential 'false positive' and 'false negative' results for infection imaging in an immunocompromised patient
• outline the mechanism of infection imaging techniques in an immunocompromised patient.
	• supervise and interpret nuclear imaging studies which assess infection, including:
	  • bone scans
	  • Ga-67
	  • labelled white cells
	  • radiolabelled anti-granulocyte antibodies
	  • F-18 FDG PET
	• identify the strengths and limitations of each of these in various clinical settings, including in immunocompromised patients
	• advise referring clinicians on the strengths and limitations of labelled leucocytes, Ga-67, F-18 FDG PET, and other radiopharmaceuticals in patients with known or suspected infection, and make recommendations on the most appropriate study to perform in specific clinical circumstances
	• recognise normal and abnormal scan appearances with the various imaging studies used to assess infection/inflammation.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.5	Infection and Inflammation Nuclear Medicine
Learning Objective 2.5.2	Recognise the emerging role of PET in the assessment of inflammation or infection
Standard	WI

Knowledge	Skills
• recognise the role that F-18 FDG PET imaging has in the evaluation of benign processes such as infection, inflammation, and granulomatous diseases • discuss the potential use and limitations of F-18 FDG PET in the assessment of a range of clinical scenarios, including fevers of unknown origin, osteomyelitis, vasculitis, sarcoidosis, and prosthetic infection, including vascular graft and orthopaedic implant.	• advise referring clinicians on the use of PET in the assessment of patients with infection and/or inflammation.

Theme 2.5 Teaching and Learning Resources

- *Nuclear Medicine in Clinical Diagnosis and Treatment*, Ell PJ and Gambhir SS (Eds), 3rd Edition, 2004, Churchill Livingston, Edinburgh
- European Association of Nuclear Medicine (EANM): EANM procedure guidelines for labelling of leucocytes with 99mTc-HMPAO: http://www.eanm.org/scientific_info/guidelines/2_EJNMMI_InfInf_GL_WBCLabelling_99mTc_04_2010.pdf
- SNM procedure guidelines for gallium scintigraphy in infection: http://interactive.snm.org/docs/Gallium_Scintigraphy_in_Inflammation_v3.pdf

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.6	In Vitro Nuclear Medicine
Learning Objective 2.6.1	Assess patients using C-14 urea breath tests to evaluate *Helicobacter pylori* infection
Standard	A

Knowledge	Skills
• explain the role of *H. pylori* in pathogenesis of peptic ulcer disease • explain the biochemistry of urea/urease in the stomach.	• supervise and interpret urea breath tests • advise referring clinicians of the advantages and disadvantages of C-14 urea breath tests over C-13 urea breath tests and serological markers of *H. pylori* infection.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.6	In Vitro Nuclear Medicine
Learning Objective 2.6.2	Assess patients using C-13/14 breath tests to evaluate intestinal absorption
Standard	A

Knowledge	Skills
• discuss the underlying pathology of small bowel bacterial overgrowth and fat malabsorption.	• supervise and interpret normal d-xylose and triolein breath tests.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.6	In Vitro Nuclear Medicine
Learning Objective 2.6.3	Assess patients using Cr-51 EDTA, Tc-99m DTPA to evaluate renal function
Standard	A

Knowledge	Skills
• describe the renal physiology of glomerular filtration and tubular secretion.	• supervise and interpret glomerular filtration rate (GFR) estimation using Cr-51 EDTA and Tc-99m DTPA • advise referring clinicians on the accuracy of GFR estimation using Cr-51 EDTA and Tc-99m DTPA as compared to other techniques.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.6	In Vitro Nuclear Medicine
Learning Objective 2.6.4	Discuss the role and use of Cr-51 RBCs to evaluate GI bleeding
Standard	A

Knowledge	Skills
• describe the pathology of GI bleeding.	• supervise and interpret a normal Cr-51 labelled RBC blood loss study.

Theme 2.6 Teaching and Learning Resources
• *Nuclear Medicine in Clinical Diagnosis and Treatment*, Ell PJ and Gambhir SS (Eds), 3rd Edition, 2004, Churchill Livingston, Edinburgh • SNM procedure guidelines for C14 urea breath tests: http://interactive.snm.org/docs/pg_ch07_0403.pdf

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.7	Musculoskeletal Nuclear Medicine
Learning Objective 2.7.1	Describe techniques of bone scintigraphy and PET imaging
Standard	I

Knowledge	Skills
• explain the mechanisms of uptake and distribution of the radiotracers, including Tc-99m labelled tracers, e.g. methylene diphosphonate (MDP)/ hydroxymethane diphosphonate (HDP) and F-18 fluoride • explain factors affecting image quality • explain the methodology of three phase bone scanning, SPECT, and SPECT/CT • explain the criteria for normal and abnormal results • obtain a thorough knowledge of cross-sectional anatomy relevant to the musculoskeletal system and integrate cross-sectional anatomy findings from SPECT/CT or PET/CT to improve sensitivity and specificity • discuss the range of normal and pathological appearances in patients • discuss the strengths and pitfalls of SPECT and SPECT/CT in musculoskeletal imaging.	• supervise and interpret bone scans and F-18 FDG PET scans for patients with musculoskeletal abnormalities • elicit a relevant history and examine the patient as required • advise technical staff on optimal patient position and imaging protocol, including CT parameters • determine if additional or alternate imaging is required • provide a succinct impression/conclusion • discuss bone scan findings with referring specialists, including sports medicine, orthopaedic, and rheumatology.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.7	Musculoskeletal Nuclear Medicine
Learning Objective 2.7.2	Assess musculoskeletal trauma
Standard	I

Knowledge	Skills
• describe the pathophysiology of bony and soft tissue injury • differentiate between primary injury and secondary compensatory effects • explain how the mechanism of injury influences interpretation of bone scans • describe the patterns of injury associated with particular sports or practices • discuss the importance of information found on blood pool images • describe the role of pinhole imaging, SPECT, and SPECT/CT in various clinical settings.	• supervise and interpret bone scans in patients with musculoskeletal trauma.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.7	Musculoskeletal Nuclear Medicine
Learning Objective 2.7.3	Assess metabolic bone disease
Standard	I

Knowledge	Skills
• discuss the role of bone scanning in metabolic bone disease, such as renal osteodystrophy, osteomalacia, hyperparathyroidism, and Paget's disease • discuss the effects of therapy for metabolic bone disease on the scan changes.	• supervise and interpret bone scans in patients with metabolic bone disease.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.7	Musculoskeletal Nuclear Medicine
Learning Objective 2.7.4	Assess skeletal infection
Standard	I

Knowledge	Skills
• discuss the advantages and disadvantages of various techniques, including In-111 or Tc-99m labelled while cell, radiolabelled monoclonal antibodies, Ga-67, and bone marrow scans • discuss which studies should be used in various clinical settings, and in what order the studies should be performed • recognise the variation in scan sensitivities in acute versus chronic infection • recognise the range of false positive findings on nuclear medicine studies in infection imaging • discuss the role of PET in the investigation of infection.	• supervise and interpret bone scans and F-18 FDG PET scans in patients with skeletal infection • advise referring clinicians on the strengths and limitations of bone scans, labelled leucocytes, Ga-67, F-18 FDG PET and other radiopharmaceuticals in patients with known or suspected skeletal infection, and make recommendations on the study to perform, including the optimal sequence for these studies.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.7	Musculoskeletal Nuclear Medicine
Learning Objective 2.7.5	Assess prosthetic joint replacements
Standard	I

Knowledge	Skills
• describe the range of pathologies and associated conditions that may occur around prostheses, e.g. osteolysis, modulus mismatch, stress fractures, loosening, and infection • describe the typical patterns of pathology associated with prostheses, e.g. loosening and infection • discuss the limitations of imaging in the evaluation of prostheses and the value of sequential imaging • describe the utility of SPECT and SPECT/CT and the artefacts that may occur around prostheses.	• supervise and interpret bone scans in patients with prosthetic joint replacements • determine the optimal sequence of nuclear medicine scans to assess for complications in patients with joint replacements • recognise normal and abnormal appearances in conditions such as infection, loosening, stress fractures, modulus mismatch, and osteolysis.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.7	Musculoskeletal Nuclear Medicine
Learning Objective 2.7.6	Assess patients following spinal surgery
Standard	I

Knowledge	Skills
• compare the role of nuclear medicine with other imaging modalities • describe normal bone scan findings following spinal surgery and the relationship of these findings to the time of surgery • describe the pathologies that occur post spinal surgery • discuss the role of SPECT and SPECT/CT, including acquisition and reconstruction parameters in this setting • describe options to assess for infection in this setting.	• supervise and interpret bone scans in patients post spinal surgery.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.7	Musculoskeletal Nuclear Medicine
Learning Objective 2.7.7	Assess arthritis and related conditions
Standard	I

Knowledge	Skills
• explain the utility of all phases of bone scan imaging in the evaluation of arthritis • discuss the role of SPECT and SPECT/CT in the evaluation of musculoskeletal pain, especially in the spine and sacroiliac joints • recognise potentially life threatening conditions such as discitis or septic arthritis • describe the non-specific nature of bone scintigraphy and the importance of pattern recognition • discuss the evolving role of F-18 FDG PET in the assessment of patients with inflammatory joint disease.	• supervise and interpret bone scans in patients with arthritis • supervise and interpret F-18 FDG PET scans in patients with arthritis.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.7	Musculoskeletal Nuclear Medicine
Learning Objective 2.7.8	Discuss the role of complementary musculoskeletal imaging modalities
Standard	WI

Knowledge	Skills
• describe the role of x-ray, CT, MRI, and ultrasound in the assessment of patients with musculoskeletal disease, including the strengths and limitations of each modality in this clinical setting. • obtain a thorough knowledge of cross-sectional anatomy relevant to the musculoskeletal system.	• interpret the results of plain film radiographs, CT, MRI, and ultrasound examinations performed on patients with musculoskeletal injury and assess the effect of these radiological findings on the interpretation of bone scans • evaluate the limitations of plain film radiography, CT, MRI, and ultrasound examinations in patients with musculoskeletal injury • advise referring practitioners of the appropriateness of specific radiological investigations in the investigation of patients with musculoskeletal disease.

Theme 2.7 Teaching and Learning Resources

- *Nuclear Medicine in Clinical Diagnosis and Treatment*, Ell PJ and Gambhir SS (Eds), 3rd Edition, 2004, Churchill Livingston, Edinburgh
- Cooper RA, Allwright SA, Anderson JA. *Atlas of Nuclear Imaging in Sports Medicine*, 2003, MacGraw Hill, Australia
- EANM procedure guidelines for bone scintigraphy: http://www.eanm.org/scientific_info/guidelines/gl_onco_bone.pdf

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.8	Neurological Nuclear Medicine
Learning Objective 2.8.1	Assess brain function using SPECT and PET
Standard	A

Knowledge	Skills
• discuss the role of functional imaging, SPECT and PET for assessment of late-life dementia • discuss the role of cerebral perfusion (SPECT) and metabolic (PET) imaging in the detection of an epileptogenic focus • describe the characteristic findings on a brain death study and potential pitfalls in interpretation • discuss the techniques and limitations of acetazolamide-stress cerebral perfusion imaging (acetazolamide/Diamox challenge test) in the assessment of cerebral perfusion reserve.	• supervise and interpret brain SPECT perfusion studies to assess dementia, epilepsy, brain death, and cerebral perfusion • supervise and interpret brain PET studies using F18-FDG to assess dementia and epilepsy • recognise the characteristic patterns of hypoperfusion/hypometabolism associated with late-life dementia syndromes - Alzheimer's disease, dementia with Lewy bodies, vascular dementia, frontotemporal dementia, and other less common sub-types • recognise the interictal and ictal patterns of perfusion (SPECT) associated with temporal lobe and other focal epilepsy types and how these evolve with time from seizure onset • recognise the interictal pattern of metabolism (PET) associated with temporal lobe and other focal epilepsy types • recognise absent intracranial perfusion to confirm brain death on planar and SPECT imaging • interpret the results for acetazolamide-stress cerebral perfusion studies • interpret results of brain perfusion/metabolism imaging on database analysis programs for brain SPECT/PET such as Neurostat 3D stereotactic surface projections (SSP).

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.8	Neurological Nuclear Medicine
Learning Objective 2.8.2	Assess disorders of CSF flow and suspected CSF leaks using scintigraphic techniques
Standard	A

Knowledge	Skills

• discuss the scintigraphic assessment of a suspected blocked CSF shunt
• discuss radiopharmaceuticals that can be used to assess a CSF shunt, and the strengths and limitations of each
• discuss the role of radionuclide cisternography in the assessment of hydrocephaly
• discuss the scintigraphic assessment of a suspected CSF leak.
	• access a CSF shunt aseptically and instil radiolabelled tracer appropriately
	• perform lumbar puncture under aseptic conditions and in a safe manner
	• supervise, and interpret CSF shunt studies, including:
	  • radionuclide shunt scintigram
	  • radionuclide cistenography
	  • CSF leak study and pledget radioactivity
	• discuss imaging techniques and use of pledgets to investigate a patient with a suspected CSF leak.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.8	Neurological Nuclear Medicine
Learning Objective 2.8.3	Identify emerging brain SPECT and PET techniques
Standard	A

Knowledge	Skills
• discuss the technique and clinical role of beta-amyloid PET imaging in the assessment of Alzheimer's disease and ageing • discuss the role of dopamine transporter SPECT and PET imaging, I-123 beta-CIT/DaTScan, F-18 DOPA etc, for the diagnosis of Parkinson's disease and dementia with Lewy bodies • discuss the potential role new PET tracers, amino acid metabolism, cell proliferation and others, for the characterisation of primary brain tumours and for the detection of recurrence.	• supervise and interpret brain beta-amyloid studies • recognise typical patterns using new and novel tracers in patients with dementia and brain tumours.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.8	Neurological Nuclear Medicine
Learning Objective 2.8.4	Assess impaired neurological function using complementary imaging techniques
Standard	WI

Knowledge	Skills
• describe the findings on CT and MRI of the common dementia types • describe the typical appearance of hippocampal sclerosis on MRI • discuss the appearance of glioma on MRI and the MRI indicators of recurrence • discuss the current technique of image fusion with nuclear medicine specialists and referring neurologists.	• interpret the results of CT scans and assess the effect of the radiological findings on the interpretation of a functional brain scan • interpret the results of cerebral MRI scans and assess the effect of the radiological findings on the interpretation of a functional brain scan • interpret the results of carotid ultrasound examination scans and assess the effect of the radiological findings on the interpretation of a cerebral perfusion scan • advise referring clinicians of the appropriateness, strengths, and limitations of complementary investigations in the investigation of patients with neurological disease.

Theme 2.8 Teaching and Learning Resources

- *Nuclear Medicine in Clinical Diagnosis and Treatment*, Ell PJ and Gambhir SS (Eds), 3rd Edition, 2004, Churchill Livingston, Edinburgh
- EANM procedure guidelines for brain F-18 FDG PET imaging: http://www.eanm.org/scientific_info/guidelines/gl_neuro_img_fdg.pdf
- EANM procedure guidelines for brain SPECT imaging: http://www.eanm.org/scientific_info/guidelines/gl_neuro_spet_radio.pdf

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.9	Oncological Nuclear Medicine
Learning Objective 2.9.1	Assess oncological disorders using F-18 FDG PET
Standard	I

Knowledge	Skills

• describe the mechanism and kinetics of F-18 FDG uptake
• describe the process of carcinogenesis and tumour growth, and describe how F-18 FDG uptake differs between normal and malignant cells
• outline the health arguments concerning the user of PET in diagnosing, staging, and restaging of malignancy
• describe which malignancies are suited to F-18 FDG imaging, and describe their incidence, prevalence and mortality in Australia and New Zealand
• describe methods of quantitation, such as use of standardised uptake value, and their use and limitations
• describe the optimal timing of image acquisition following injection, and the role of multiphase imaging
• describe various acquisition protocols for PET and CT components, including the use of oral or intravenous contrast
• describe patterns of physiologic F-18 FDG uptake, especially ones that should not be misinterpreted as pathologic
• recognise issues related to attenuation correction and misregistration of PET and CT
• be able to identify other unsuspected pathology on PET or CT
• describe methods of response assessment for PET, e.g. PET response evaluation criteria in solid tumours (PERCIST) and its limitations
• describe methods of response assessment for CT, including response evaluation criteria in solid tumours (RECIST)
• describe the utility of PET for radiation therapy treatment planning
	• supervise and interpret F-18 FDG PET scans in patients with malignancy
	• advise referring clinicians on the benefits, accuracy, potential pitfalls, and suitability of F-18 FDG-PET in patients with malignancy
	• take an appropriate history of the patient
	• determine the patient preparation conditions to permit optimal F-18 FDG-PET scan, e.g. patient with elevated blood glucose, high brown fat activity, or claustrophobia; positioning for radiation therapy treatment planning
	• prepare a comprehensive PET report combining metabolic and anatomic information, including a clear and succinct impression/conclusion
	• communicate findings at multidisciplinary team meetings
	• assess the need and/or contraindications for CT contrast media
	• assess CT image quality and identification of artefacts
	• interpret a sufficient number of PET to assess utility, sources of error, normal variants, and artefacts, including ability to:
	  • assign PET/SPECT abnormalities to anatomic structures
	  • assimilate CT appearances into assessment of PET/SPECT findings
	  • recognise CT abnormalities that are not associated with radiotracer abnormality.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.9	Oncological Nuclear Medicine
Learning Objective 2.9.1	Assess oncological disorders using F-18 FDG PET

- explain the causes of false negative and false positive studies as well as PET imaging artefacts
- describe the optimum time for scanning of F-18 FDG scans in relation to surgery, chemotherapy, and radiotherapy
- describe the role of F-18 FDG PET in the management of carcinomas of unknown primary site
- obtain a thorough knowledge of cross-sectional anatomy and normal variants as demonstrated by CT
- describe CT protocols for PET/CT & SPECT/CT
- describe use of GI and intravenous CT contrast media, including indications, contraindications, and possible effects on attenuation correction algorithms
- recognise the appearances of benign and malignant processes
- recognise limitations of CT imaging when a low dose non-contrast PET/CT or SPECT/CT protocol is used.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.9	Oncological Nuclear Medicine
Learning Objective 2.9.2	Assess patients with lung cancer
Standard	I

Knowledge	Skills
• discuss the pathological classification of lung cancer and describe the role of F-18 FDG PET in non-small cell lung cancer vs. small-cell cancer • describe the tumour node metastasis (TNM) staging system for lung cancer • describe the common patterns of spread of lung cancer, in particular in terms of primary tumour, nodal and distant metastatic involvement • describe the pathologic and prognostic features that assist in determining indications for therapy • describe the role of surgery, chemotherapy or radiotherapy for management • describe how F-18 FDG PET may influence the choice of management • describe the indications of F-18 FDG PET to assist diagnosis, staging, and restaging • describe the role of F-18 FDG PET for early response assessment and how this may direct alternative treatment, and avoid morbidity, toxicity, or cost of ineffective treatment • describe reporting thresholds for diagnosing malignancy in patients with a solitary pulmonary nodule (SPN) including how to integrate pre-test probability, PET, and CT findings to reach a conclusion • describe the causes of a false negative or positive results in patients with SPN • explain appropriate further investigation or follow-up in patients with a SPN • recognise issues related to respiratory misregistration and how this can be reduced • describe the complementary role of oesophageal and endobronchial ultrasound, and medianoscopy for staging • describe the role of a dedicated radiation therapy planning study, and how to perform this • describe the role of molecular targeted agents in the treatment of advanced disease.	• supervise and interpret F-18 FDG PET scans in patients with lung cancer • supervise and interpret F-18 FDG PET scans in patients with solitary pulmonary nodules • supervise and interpret F-18 FDG PET scans in patients being planned for radiotherapy • advise referring clinicians on the benefits, accuracy, potential pitfalls and limitations of F-18 FDG-PET in patients with lung cancer • advise referring clinicians on the benefits, accuracy, potential pitfalls and limitations of F-18 FDG-PET in patients with a solitary pulmonary nodule.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.9	Oncological Nuclear Medicine
Learning Objective 2.9.3	Assess patients with GI malignancies
Standard	I

Knowledge	Skills
• discuss the pathological classification of gastro-oesophageal cancer and colorectal cancer • describe the TNM staging system for gastro-oesophageal cancer and colorectal cancer • describe the common patterns of spread of gastro-oesophageal cancer and colorectal cancer, in particular in terms of primary tumour, nodal, and distant metastatic involvement • describe the pathologic and prognostic features that assist in determining indications for therapy • describe the role of surgery, chemotherapy, or radiotherapy for management • describe how F-18 FDG PET may influence the choice of management • describe the indications of F-18 FDG PET to assist diagnosis, staging, and restaging • describe indications for use in colorectal cancer, e.g. initial staging, pre-sacral soft tissue change post surgery, rising carcinoembryonic antigen (CEA), prior to metastastectomy, radiotherapy planning, and relevance of incidental colonic uptake • describe the complementary role of endoscopic ultrasound for staging oesophageal malignancy • identify the subtypes of gastric carcinoma where F-18 FDG PET has a limited role, and describe features on CT that may suggest non-F-18 FDG avid but aggressive disease • describe indications for F-18 FDG in other GI malignancies, i.e. primary liver, pancreatic and gallbladder malignancy • describe the role of F-18 FDG PET for early response assessment and how this may direct alternative treatment and avoid morbidity, toxicity, or cost of ineffective treatment.	• supervise and interpret F-18 FDG PET scans in patients with gastro-oesophageal cancer • supervise and interpret F-18 FDG PET scans in patients with colorectal cancer • advise referring clinicians on the benefits, accuracy, potential pitfalls and limitations of F-18 FDG-PET in patients with gastro-oesophageal cancer • advise referring clinicians on the benefits, accuracy, potential pitfalls and limitations of F-18 FDG-PET in patients with colorectal cancer.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.9	Oncological Nuclear Medicine
Learning Objective 2.9.4	Assess patients with breast cancer
Standard	A

Knowledge	Skills
• discuss the pathological classification of breast cancer • describe the TNM staging system of breast cancer • describe the common patterns of spread of breast cancer, in particular primary tumour, nodal, and distant metastatic involvement • describe the pathologic and prognostic features that assist in determining indications for therapy • describe the role of surgery, chemotherapy, or radiotherapy for management • describe how F-18 FDG PET may influence the choice of management • describe the indications of F-18 FDG PET to assist diagnosis, staging, and restaging • describe role for staging in patients with locally advanced disease compared to CT and bone scintigraphy • describe limitations compared to sentinel node biopsy for locoregional nodal staging • describe role in detection and response assessment of marrow metastases and contrast with bone scintigraphy • describe role for differentiating axillary post-radiotherapy change from tumour recurrence • describe the role of lymphoscintigraphy (see learning objective 2.9.14).	• supervise and interpret F-18 FDG PET scans in patients with breast cancer • advise referring clinicians on the benefits, accuracy, potential pitfalls and limitations of F-18 FDG-PET in patients with breast cancer • supervise, perform, and interpret lymphoscintgraphy in patients with breast cancer • advise referring clinicians on the accuracy and potential limitations of lymphoscintigraphy in patients with breast cancer.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.9	Oncological Nuclear Medicine
Learning Objective 2.9.5	Assess patients with head and neck malignancies
Standard	I

Knowledge	Skills
• discuss the pathological classification of head and neck cancer • describe the TNM staging system of head and neck cancer • describe the common patterns of spread of head and neck cancer, in particular in terms of primary tumour, nodal, and distant metastatic involvement • describe the pathologic and prognostic features that assist in determining indications for therapy • describe the role of surgery, chemotherapy, or radiotherapy for management • describe how F-18 FDG PET may influence the choice of management • describe the indications of F-18 FDG PET to assist diagnosis, staging, and restaging • describe the relevant clinical assessment methods, including the role of panendoscopy • describe the role of staging for selecting surgery or radiation therapy as definitive therapy • describe the role in squamous cell carcinoma (SCC) of unknown primary • describe the strengths and limitations for restaging following definitive radiotherapy • describe the role of I-131 and F-18 FDG PET in the evaluation of patients with different types of thyroid cancer (see also learning objective 4.1.2) • describe how the avidity of I-131 and F-18 FDG varies according to the pathological subtype and the degree of differentiation.	• supervise and interpret F-18 FDG PET scans in patients with head and neck cancer • advise referring clinicians on the benefits, accuracy, potential pitfalls, and limitations of F-18 FDG-PET in patients with head and neck cancer • advise referring clinicians on the role of I-131 vs. F-18 FDG PET in patients with various subtypes of thyroid cancer.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.9	Oncological Nuclear Medicine
Learning Objective 2.9.6	Assess patients with melanoma
Standard	I

Knowledge	Skills
• discuss the pathological classification of melanoma • describe the TNM staging system of melanoma • describe the common patterns of spread of melanoma, in particular in terms of primary tumour, nodal, and distant metastatic involvement • describe the pathologic and prognostic features that assist in determining indications for therapy • describe the role of surgery, chemotherapy, or radiotherapy for management • describe how F-18 FDG PET may influence the choice of management • describe the indications of F-18 FDG PET to assist diagnosis, staging, and restaging • describe limitations of F-18 FDG compared to sentinel node biopsy for locoregional nodal staging • describe role of F-18 FDG, especially in the surgical workup of a patient with isolated locoregional nodal disease or prior to metastectomy • describe the role of lymphoscintigraphy (see learning objective 2.9.14).	• supervise and interpret F-18 FDG PET scans in patients with melanoma • advise referring clinicians on the benefits, accuracy, potential pitfalls, and limitations of F-18 FDG-PET in patients with melanoma • supervise, perform, and interpret lymphoscintigraphy in patients with melanoma • advise referring clinicians on the accuracy and potential limitations of lymphoscintigraphy in patients with melanoma.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.9	Oncological Nuclear Medicine
Learning Objective 2.9.7	Assess patients with neuroendocrine tumours
Standard	A

Knowledge	Skills
• discuss the pathological classification of neuroendocrine tumours • describe the TNM staging system of neuroendocrine tumours • describe the common patterns of spread of neuroendocrine tumours, in particular in terms of primary tumour, nodal, and distant metastatic involvement • describe the role somatostatin receptor imaging (SRI) and MIBG in neuroendocrine/carcinoid tumours, phaeochromocytoma/paraganglioma and neuroblastoma • describe pathologic and prognostic features that assist in determining indications for therapy, and the role of surgery, chemotherapy, or radiotherapy • describe the principles of SRI, recognising the range of different receptors expressed on different tumour types • describe the mechanisms of MIBG uptake in this diverse range of tumours • compare the sensitivities and specificities of MIBG and SRI • describe patient preparation required for MIBG or SRI, e.g. medications that may interfere with MIBG, cessation of octreotide for SRI and thyroid preparation for I-131 MIBG • describe the role of SRI in other tumours that express somatostatin-receptors, e.g. mesenchymal tumours, medullary thyroid carcinoma, and well-differentiated brain tumours • describe which gastroenteropancreatic neuroendocrine tumours (GEPNETs) are most suited to imaging with In-111 octreotide • describe the added value and optimal protocols for performing SPECT/CT with In-111 octreotide • describe the differences between In-111 octreotide and Ga-68 labelled analogues, and indications where PET imaging may have a high management impact	• supervise and interpret scans using In-111 octreotide (and Ga-68 analogues) in patients with neuroendocrine tumours undergoing SRI • supervise and interpret radioiodinated MIBG scans in patients with neuroendocrine tumours • supervise and interpret F-18 FDG PET scans in patients with neuroendocrine tumours • advise referring clinicians on the strengths and limitations of In-111 octreotide, Ga-68 dotatate (and analogues), radioiodinated MIBG, F-18 FDG PET and other radiopharmaceuticals in patients with known or suspected neuroendocrine tumours, and make recommendations on the most appropriate study to perform.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.9	Oncological Nuclear Medicine
Learning Objective 2.9.7	Assess patients with neuroendocrine tumours

• describe reporting criteria that may indicate suitability for peptide receptor radionuclide therapy (PRRT) • describe the relevance of a negative study in a patient with known disease, and the complementary role of F-18 FDG PET in differentiating well vs. poorly differentiated disease • describe how SRI and PET may influence the choice of management • describe the indications of SRI and PET to assist diagnosis, staging, and restaging.	

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.9	Oncological Nuclear Medicine
Learning Objective 2.9.8	Assess patients with lymphoma and other haematological malignancies
Standard	I

Knowledge	Skills
• discuss the pathological classification of lymphoma • describe different types of high-grade and low-grade non-Hodgkin's lymphoma, including knowledge of when treatment or observation may be appropriate • describe staging and scoring systems and how these may be altered with F-18 FDG PET staging, including the Ann Arbor stage, International Prognostic Index (IPI) and the Follicular Lymphoma International Prognostic Index (FLIPI) • describe the common patterns of spread of lymphoma, in particular in terms of primary tumour, nodal, and distant metastatic involvement • describe the common treatment regimens for Hodgkin's and non-Hodgkin's lymphoma, and how these may influence PET findings, e.g. hematopoietic growth factors and marrow change, bleomycin and pulmonary toxicity	• supervise and interpret F-18 FDG PET scans in patients with lymphoma • supervise and interpret F-18 FDG PET scans in patients with other haematological malignancies, e.g. myeloma • advise referring clinicians on the benefits, accuracy, potential pitfalls and limitations of F-18 FDG-PET in patients with lymphoma and other haematological malignancies • supervise and interpret radiolabelled monoclonal antibody scans prior to treatment in patients with lymphoma and other haematological malignancies. Advise on appropriate clinical indications for their use and be aware of their limitations.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.9	Oncological Nuclear Medicine
Learning Objective 2.9.8	Assess patients with lymphoma and other haematological malignancies

- describe advantages of PET compared to conventional imaging for staging
- outline other pathologies that can have F-18 FDG uptake especially in the immunocompromised
- describe the role of PET to assess a residual mass following treatment
- describe the role of PET in patients with stage 1 follicular lymphoma on conventional workup
- describe the role and timing of PET for early restaging in different subtypes of lymphoma, and be aware of how findings may direct an early change management
- describe advantages of F-18 FDG compared to Ga-67
- describe the role of PET in other haematologic malignancies, e.g. myeloma
- describe the pathologic and prognostic features that assist in determining indications for therapy
- describe the role of surgery, chemotherapy, or radiotherapy for management
- describe how F-18 FDG PET may influence the choice of management
- describe the indications of F-18 FDG PET to assist diagnosis, staging, and restaging
- describe the role of radiolabelled antibody studies (e.g. I-131 or Y-90 labelled anti-CD20 antibodies) prior to treatment of lymphoma, leukaemia, and myeloma (also see learning objective 4.1.5).

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.9	Oncological Nuclear Medicine
Learning Objective 2.9.9	Assess patients with gynaecological malignancies
Standard	I

Knowledge	Skills
• discuss the pathological classification of gynaecological malignancies, especially cancers of the ovary, cervix, and uterus • describe the TNM staging system for gynaecological malignancies • describe the common patterns of spread of gynaecological malignancies, in particular in terms of primary tumour, nodal, and distant metastatic involvement • describe the pathologic and prognostic features that assist in determining indications for therapy • describe the role of surgery, chemotherapy, or radiotherapy for management • describe how F-18 FDG PET may impact the choice of management • describe the indications of F-18 FDG PET to assist diagnosis, staging, and restaging • describe the prognostic utility in cervical cancer staging compared to other staging methods, such as clinical assessment or MRI • describe use to guide radiation therapy in cervical, vulvar, or vaginal cancers • describe the role for detection of recurrent ovarian cancer, e.g. in the setting of raised cancer antigen (CA) 125 • describe indications in a patient with endometrial cancer.	• supervise and interpret F-18 FDG PET scans in patients with gynaecological malignancies • advise referring clinicians on the benefits, accuracy, potential pitfalls, and limitations of F-18 FDG-PET in patients with gynaecological malignancies.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.9	Oncological Nuclear Medicine
Learning Objective 2.9.10	Assess patients with sarcoma
Standard	I

Knowledge	Skills
• discuss the pathological classification of sarcoma • describe the TNM staging system for sarcoma • describe the common patterns of spread of sarcoma, in particular in terms of primary tumour, nodal, and distant metastatic involvement • describe the pathologic and prognostic features that assist in determining indications for therapy • describe the role of surgery, chemotherapy, or radiotherapy for management • describe how F-18 FDG PET may influence the choice of management • describe the indications of F-18 FDG PET to assist diagnosis, staging and restaging • describe the role to assist in diagnosis by targeting region of greatest metabolic activity • describe use for restaging prior to consideration of limb-preserving surgery for primary bone sarcoma • describe unique role in GI stromal tumour (GIST) management, particularly in relation to response assessment following targeted therapy with tyrosine kinase inhibitors.	• supervise and interpret F-18 FDG PET scans in patients with sarcoma • advise referring clinicians on the benefits, accuracy, potential pitfalls, and limitations of F-18 FDG-PET in patients with sarcoma.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.9	Oncological Nuclear Medicine
Learning Objective 2.9.11	Assess primary bone tumours
Standard	A

Knowledge	Skills
• discuss the pathological classification of primary bone tumours • describe the TNM staging system of primary bone tumours • describe the common patterns of spread of primary bone tumours, in particular in terms of primary tumour, nodal, and distant metastatic involvement • describe the pathologic and prognostic features that assist in determining indications for therapy • describe the role of surgery, chemotherapy, or radiotherapy for management • describe how F-18 FDG PET may influence the choice of management • describe the indications of F-18 FDG PET to assist diagnosis, staging, and restaging • describe the role and limitations of other radiopharmaceuticals in the evaluation of primary bone tumours, including Tc-99m MDP, Tl-201, and Tc-99m sestamibi/Tc-99m tetrofosmin • discuss the role of alternate modalities in the investigation, staging, and monitoring of primary bone tumours e.g. MRI.	• supervise and interpret F-18 FDG PET scans in patients with primary bone tumours • advise referring clinicians on the benefits, accuracy, potential pitfalls, and limitations of F-18 FDG PET in patients with primary bone tumours • supervise and interpret single photon studies in patients with primary bone tumours, using radiopharmaceuticals such as Tc-99m MDP, Tl-201, and Tc-99m sestamibi/Tc-99m tetrofosmin • advise referring clinicians on the strengths and limitations of Tc-99m MDP, Tl-201, and Tc-99m sestamibi/Tc-99m tetrofosmin compared with F-18 FDG PET in patients with primary bone tumours and make recommendations on the most appropriate study to perform.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.9	Oncological Nuclear Medicine
Learning Objective 2.9.12	Assess skeletal metastatic disease
Standard	I

Knowledge	Skills
• describe pathophysiology of malignant bone disease, including lytic and sclerotic metastases • describe the limitations of bone scintigraphy in patients with lytic/marrow metastases • describe advantages of SPECT and SPECT/CT and how to use CT to improve sensitivity and specificity for staging and restaging • describe use and limitations of F-18 fluoride PET, F-18 FDG, and Tc-99m bone scans in the assessment of skeletal metastases • recognise patterns of benign aetiology such as degenerative disease and Paget's disease • describe how to approach a patient with a suspected solitary osseous metastasis • differentiate between a 'flare response' and progressive disease • recognise when it is appropriate to suggest treatment with bone palliation radionuclide therapy.	• supervise and interpret Tc-99m bone scans in patients with skeletal metastases, ensuring that appropriate protocols are used, including early phase imaging if appropriate to identify non-osseous/soft tissue disease • supervise and interpret F-18 FDG PET scans in patients with skeletal metastases • supervise and interpret F-18 bone scans in patients with skeletal metastases • advise referring clinicians on the benefits, accuracy, potential pitfalls, and limitations of F-18 FDG PET in patients with skeletal metastases • use correlative radiological images to aid interpretation of scan findings • identify sites of osseous metastases that confer a high risk of pathologic fracture, and may warrant urgent orthopaedic review.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.9	Oncological Nuclear Medicine
Learning Objective 2.9.13	Assess patient with brain malignancy
Standard	A

Knowledge	Skills
• discuss the pathological classification of brain tumours • describe the common patterns of spread of brain tumours, in particular in terms of primary tumour, nodal, and distant metastatic involvement • describe the pathologic and prognostic features that assist in determining indications for therapy • describe the role of surgery, chemotherapy, or radiotherapy for management • describe how F-18 FDG PET may influence the choice of management • describe the indications of F-18 FDG PET to assist diagnosis, staging, and restaging • discuss the use and limitations of F-18 FDG PET in the assessment of a patient with primary brain malignancy. • describe role in differentiation of post radiotherapy change from malignancy • discuss the use and limitations of TI-201 in the assessment of a patient with primary brain malignancy • discuss the use and limitations of new SPECT and PET radiopharmaceuticals in the assessment of a patient with primary brain malignancies.	• supervise and interpret Tl-201 brain SPECT studies in patients with cerebral malignancy • supervise and interpret F18-FDG brain PET studies in patients with cerebral malignancy • advise referring clinicians on the benefits, accuracy, potential pitfalls, and limitations of F-18 FDG PET in patients with primary brain tumours • recognise abnormal thallium uptake in brain SPECT for tumour imaging • recognise abnormal F-18 FDG uptake for characterising suspected primary brain tumour and for detection of recurrence.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.9	Oncological Nuclear Medicine
Learning Objective 2.9.14	Assess patients using lymphoscintigraphy
Standard	I

Knowledge	Skills
• describe the different protocols for injection and imaging sentinel nodes • describe the application for staging in breast carcinoma and melanoma, and be aware of increasing use in other malignancies • describe the common lymphatic drainage patterns depending on primary site • describe the reason for false negative and false positive studies • describe the additional value of SPECT/CT and when to use it • describe the various drainage patterns seen in evaluating patients with lymphoedema.	• supervise and interpret lymphoscintigraphy studies, especially for breast cancer and melanoma • perform injections, either perilesional or periareolar, with or without ultrasound guidance, according to standard protocols • identify the site of sentinel node, mark it for surgery, and communicate results with the referring surgeon • observe the use of intraoperative probe and dye localisation techniques at time of operation • advise referring clinicians on the accuracy and potential limitations of lymphoscintigraphy in patients with breast cancer, melanoma, and other malignancies.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.9	Oncological Nuclear Medicine
Learning Objective 2.9.15	Use SPECT and PET tracers (other than F-18 FDG) to characterise tumours
Standard	A

Knowledge	Skills

• describe the role of single photon radiopharmaceuticals in the evaluation of certain malignancies, e.g.
  • myeloma with Tc-99m sestamibi
  • breast carcinoma using Tc-99m sestamibi
  • medullary thyroid carcinoma with Tc-8m DMSA (V)
• outline the role of monoclonal labelled antibodies such as anti-CEA for tumour imaging
• discuss how SPECT and SPECT/CT imaging can enhance diagnostic confidence and accuracy in oncological imaging
• identify current clinical indications of PET tracers other than F-18 FDG and indications for referral to a centre that can perform the study
• describe metabolic pathways other than glucose metabolism and how these can be imaged with PET, such as:
  • amino-acid metabolism, e.g. C-11 methionine (MET) for brain tumours
  • tumour proliferation with thymidine analogues, e.g. F-18 FLT
  • phosphocholine formation, e.g. F-18 fluorocholines in prostate cancer
• describe use of PET for tumour receptor imaging, including:
  • steroid receptor imaging, e.g. fluoro-oestradiol (FES) in breast carcinoma
  • growth factor imaging, e.g. radiolabelled human epidermal growth factor receptor 2 (HER2)
• describe utility of PET for hypoxia imaging, e.g. F-18 FMISO.
	• supervise and interpret scans using single photons to assess certain malignancies
	• supervise and interpret PET scans using radiopharmaceuticals other than F-18 FDG to assess certain malignancies
	• advise referring clinicians on the benefits, accuracy, potential pitfalls, and limitations of non- F-18 FDG PET agents as well as various single photon radiopharmaceuticals in patients with different malignancies.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.9	Oncological Nuclear Medicine
Learning Objective 2.9.16	Explain the use of radiological imaging to assist in the interpretation of oncological nuclear medicine studies
Standard	WI

Knowledge	Skills
• explain how MRI, ultrasound, and other radiological modalities may assist the interpretation of oncological nuclear medicine studies • discuss the strengths and limitations of radiological modalities when used in conjunction with nuclear medicine studies.	• correlate nuclear medicine findings with other methods of assessment, e.g. MRI • advise referring clinicians of the appropriateness, strengths, and limitations of complementary investigations in the investigation of patients with cancer.

Theme 2.9 Teaching and Learning Resources

- *Nuclear Medicine in Clinical Diagnosis and Treatment*, Ell PJ and Gambhir SS (Eds), 3rd Edition, 2004, Churchill Livingston, Edinburgh
- RECIST: http://www.eortc.be/recist/default.htm
- Edge SB, Byrd DR *et al.* (Editors) *AJCC Cancer Staging Manual,* 7th Edition, 2009. Springer. ISBN-10: 0387884408
- Barrington SF, Maisey MN, Wahl RL, *Atlas of Clinical Positron Emission Tomography, 2nd Edition, 2006, Oxford University Press, New York, NY*
- EANM procedure guidelines for sentinel node imaging in breast cancer: http://www.eanm.org/scientific_info/guidelines/gl_onco_sent_node.pdf
- EANM procedure guidelines for sentinel node imaging in melanoma: http://www.eanm.org/scientific_info/guidelines/gl_onco_eanm_eortc.pdf
- SNM procedure guidelines for SPECT/CT imaging: http://interactive.snm.org/docs/jnm32961_online.pdf
- SNM procedure guidelines for PET/CT tumour imaging: http://interactive.snm.org/docs/jnm30551_online.pdf

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.10	Evaluation of Osteoporosis
Learning Objective 2.10.1	Describe techniques used to evaluate osteoporosis
Standard	I

Knowledge	Skills
• describe advantages and disadvantages of dual energy x-ray absorptiometry over quantitative computerised tomography and quantitative ultrasound in terms of accuracy, reproducibility, and radiation safety • describe the technical differences between the various commercially available dual energy x-ray absorptiometers • describe methods used to account for factors relating to inter-machine variability.	• discuss the different BMD reference ranges available and the implications of these on diagnosis.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.10	Evaluation of Osteoporosis
Learning Objective 2.10.2	Assess quality assurance procedures in bone mineral density (BMD) estimation
Standard	I

Skills
• calculate the in vivo and in vitro reproducibility of the dual photon bone densitometer used at the training site • calculate the least significant change for the lumbar spine, total proximal femur, femoral neck, and total body at the training site • discuss quality assurance procedures relative to BMD studies.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.10	Evaluation of Osteoporosis
Learning Objective 2.10.3	Interpret and report lumbar spine BMD scans
Standard	I

Knowledge	Skills

• list common artefacts and anatomical variants that may alter scan interpretation
• articulate and justify the criteria necessary to determine that a significant interval change in lumbar spine BMD has occurred.
	• supervise and interpret BMD studies of the lumbar spine
	• articulate and justify the indications for performing a lumbar spine BMD scan in males and females
	• communicate the interpretation of lumbar spine BMD scans to referring clinicians
	• discuss with a referring clinician the role of lumbar spine BMD scans in monitoring the patient with osteoporosis, osteopenia, and normal lumbar BMD
	• discuss indications for performing, in males and females, BMD scans of:
	  • lumbar spine
	  • proximal femur
	  • appendicular site
	  • total body
	• discuss significant change in results
	• discuss use of BMD in monitoring therapy for osteoporosis
	• communicate interpretation of BMD scan to referring practitioner.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.10	Evaluation of Osteoporosis
Learning Objective 2.10.4	Interpret and report proximal femur BMD scans
Standard	I

Knowledge	Skills
• list common artefacts and anatomical variants that may alter scan interpretation • describe the relationship between BMD assessment in the lumbar spine and in the proximal femur.	• supervise and interpret BMD studies of the proximal femur • outline and justify the indications for performing a proximal femur BMD scan in males and females • outline and justify the criteria necessary to determine that a significant interval change in femoral BMD has occurred • communicate the interpretation of proximal femur BMD scans to referring clinicians • discuss with a referring clinician the role of proximal femur BMD scans in monitoring the patient with osteoporosis, osteopenia, and normal lumbar BMD.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.10	Evaluation of Osteoporosis
Learning Objective 2.10.5	Assess BMD in appendicular skeleton
Standard	A

Knowledge	Skills
• discuss the use and limitations of the appendicular BMD scan technique and of the interpretation criteria used with nuclear medicine specialists and referring practitioners.	• supervise and interpret appendicular BMD scans • recognise and interpret a normal appendicular BMD scan.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.10	Evaluation of Osteoporosis
Learning Objective 2.10.6	Assess total body bone mineral and body composition
Standard	A

Knowledge	Skills
• discuss the use and limitations of the total body bone mineral and body composition scan technique and of the interpretation criteria used with nuclear medicine specialists and referring practitioners.	• supervise and interpret total body bone mineral and body composition scans • discuss limitations of total body bone mineral and body composition in various clinical cases.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.10	Evaluation of Osteoporosis
Learning Objective 2.10.7	Outline absolute fracture risk
Standard	WI

Knowledge	Skills
• recognise the need and utility in calculating absolute fracture risk in males and females • list assumptions in calculating absolute fracture risk.	• communicate absolute fracture risk to referring clinicians • discuss with a referring clinician the role of absolute fracture risk in assessing the patient with osteoporosis, osteopenia, and normal lumbar BMD.

Theme 2.10 Teaching and Learning Resources

- Kanis JA, Black D, Cooper C, Dargent P, Dawson-Hughes B, De Laet C, Delmas P, Eisman J, Johnell O, Jonsson B, Melton LJ, Oden A, Papapoulos S, Pols H, Rizzoli R, Silman A, Tenenhouse A. A new approach to the development of assessment guidelines for osteoporosis. *Osteoporosis International* 2002: 13; 527-536.
- Assessment of 10-year absolute fracture risk: a new paradigm with worldwide application. E. Siris and P. D. Delmas. *Osteoporosis International* 2008 April; 19(4): 383–384.
- Bone Genetics and Epidemiology Research Group, Garvan Institute: http://www.garvan.org.au/research/research-groups/dubbo-epidemiology-study.html
- WHO Fracture Risk Assessment Tool (FRAX®): http://www.sheffield.ac.uk/FRAX/tool.jsp

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.11	Pulmonary Nuclear Medicine
Learning Objective 2.11.1	Describe the assessment, management, and outcomes of pulmonary embolism (PE) and deep venous thrombosis (DVT)
Standard	I

Knowledge

- describe the epidemiology, risk factors, and treatment of DVT and PE
- describe the mortality and morbidity of treated and untreated DVT and PE
- describe the recurrence rate of DVT and PE and its long-term sequelae
- describe the clinical signs and symptoms of DVT and PE and their sensitivity and specificity in the detection and exclusion of PE
- describe non-scintigraphic methods of DVT detection, including contrast venography, compression ultrasound, and impedance plethysmography. List the sensitivity, specificity, and limitations of each technique.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.11	Pulmonary Nuclear Medicine
Learning Objective 2.11.2	Assess PE using ventilation and perfusion imaging
Standard	I

Knowledge	Skills

• describe the 'method of action', physical properties, half life, and biodistribution of the available ventilation agents, including:
  • Xe-133
  • Tc-99m DTPA aerosol
  • Tc-99m Technegas
  • Tc-99m Pertechnegas
  • Kr-81m
• describe the method of administration of each of these agents
• discuss the advantages and disadvantages of each of these tracers
• discuss the impact of choice of ventilation agent and study protocol with regard to applicability in the Australian and New Zealand settings
• describe the 'method of action', physical properties, half life, and pharmacokinetics of perfusion agents
• discuss the safety of the perfusion agents, including the particular risks associated with those agents derived from human plasma
• describe the dosimetry estimates for ventilation agents and perfusion agents
• explain the different planar interpretation criteria, including prospective investigation of PE diagnosis (PIOPED), revised PIOPED, other relevant criteria, and the reasons for their refinement
• discuss the strengths and weaknesses of planar and SPECT lung scanning
• describe the criteria for interpretation of SPECT lungs scans
• explain the application of Bayesian analysis to diagnostic test, in particular lung scan, interpretation
• describe the benefits and limitations of SPECT/CT and V/Q scans
	• devise an imaging protocol using ventilation and perfusion agents, as well as image acquisition and processing techniques that will optimise the diagnostic accuracy of the study
	• define the variations required in special circumstances, such as pregnancy, for lung ventilation and lung perfusion studies
	• advise the patient and referring clinician on the required time of interruption to breastfeeding if appropriate
	• supervise and interpret lung scans in patients with PE, using both planar and SPECT methodology
	• provide a succinct and clear report of a lung scan based on established criteria
	• provide an accurate description of the segmental location and size of any perfusion defect
	• undertake a Bayesian analysis in the interpretation of lung scans of patients suspected of PE, and discuss the limitations of this approach with a referring clinician
	• manage cases of suspected PE, with scintigraphic intermediate probability or inconclusive report, in accordance with accepted guidelines
	• communicate the interpretation of lung scans to referring clinicians in cases of suspected PE, fat emboli, and pulmonary arterial hypertension
	• discuss with the referring clinician the role of lung scanning in monitoring the patient with definite PE.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.11	Pulmonary Nuclear Medicine
Learning Objective 2.11.2	Assess PE using ventilation and perfusion imaging

• obtain a thorough knowledge of cross-sectional anatomy of the thorax, especially in relation to lung segmental anatomy • determine the reproducibility of lung scan reports.	

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.11	Pulmonary Nuclear Medicine
Learning Objective 2.11.3	Discuss the role of ancillary tests and complementary imaging techniques for PE
Standard	WI

Knowledge	Skills
• interpret the results of arterial blood gas measurements on to the detection of PE • interpret the results of serum D-dimer assays • interpret chest radiography reports for patients with PE • interpret ECG findings in patients with PE • interpret the results of contrast venography and non-invasive tests for DVT in patients with suspected pulmonary thrombosis • describe the strengths and limitations of CT pulmonary angiography (CTPA) • describe the methodology for performing CTPA • describe the radiation dose received by the patient for both lung scanning and CTPA on both a whole body basis and on an individual organ basis for 'sensitive' target organs.	• analyse clinical cases of patients suspected of PE to identify, and advise referring clinicians, the most appropriate test to be performed to rule in or out acute PE and chronic PE • analyse clinical cases of patients suspected of PE to identify the most appropriate tests to perform following an inconclusive lung scan • advise referring clinicians as to which is the appropriate test for breastfeeding or pregnant patients • use prior imaging and diagnostic test results, including CTPA, to assist in formulating an accurate lung scan report • recognise PE in CTPA images as well as recognise technically suboptimal and potential false positive CTPA studies.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.11	Pulmonary Nuclear Medicine
Learning Objective 2.11.4	Assess patients by quantitation of lung ventilation and perfusion
Standard	I

Knowledge	Skills

• describe different approaches to lung quantitation methods, including geometric mean and SPECT segmentation
• describe the anatomy of:
  • intrathoracic great vessels
  • alterations in congenital heart disease
  • further alterations following surgical correction
• recognise the pathophysiology of right to left shunts and pulmonary hypertension, and the risks of injecting MAA particles in these settings.
	• select the most appropriate imaging tracers to answer the clinical question
	• advise on whether ventilation or perfusion only, or a combined study, is required
	• determine the best acquisition methodology, including administered activities, order of studies, and choice of planar, SPECT, or SPECT/CT imaging
	• advise the best method for quantitation analysis to answer the clinical question
	• supervise and interpret V/Q scans for quantitation of lung ventilation and perfusion
	• describe the limitations and technical problems related to quantitation of V/Q scans.

DOMAIN 2	DIAGNOSTIC NUCLEAR MEDICINE
Theme 2.11	Pulmonary Nuclear Medicine
Learning Objective 2.11.5	Assess inflammatory lung disease
Standard	A

Knowledge	Skills
• explain the nature of tracers used for inflammation imaging and lung clearance studies, including Ga-67, F18-FDG, aerosolised Tc-99m DTPA and per Pertechnegas • describe the method of acquiring scans with both F-18 FDG PET and Ga-67 imaging • discuss the relative dosimetry of Ga-67 and F-18 FDG • recognise and interpret the characteristics of normal and abnormal Ga-67 and F-18 FDG-PET scans • explain the physiologic and pathophysiologic basis of normal and abnormal lung clearance studies • explain the method of analysis and interpretation of lung clearance studies • identify factors that may interfere with lung clearance study interpretation, such as smoking.	• supervise and interpret V/Q scans and F18-FDG PET scans in the assessment of lung inflammation • advise referring practitioners of the appropriateness, strengths, and limitations of Ga-67 and F-18 FDG PET in the evaluation of patients with inflammatory lung disease • explain the optimal scan acquisition protocols for both the single photon and PET methods.

Theme 2.11 Teaching and Learning Resources

- *Nuclear Medicine in Clinical Diagnosis and Treatment*, Ell PJ and Gambhir SS (Eds), 3rd Edition, 2004, Churchill Livingston, Edinburgh
- European Association of Nuclear Medicine (EANM): EANM Guidelines for Ventilation / Perfusion Scintigraphy - Part 1 and Part 2: http://www.eanm.org/scientific_info/guidelines/gl_pulm_embolism_part1.pdf http://www.eanm.org/scientific_info/guidelines/gl_pulm_embolism_part2.pdf
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- Morrell NW, Roberts C, Jones B, Nijran K, Biggs T, Seed W. The anatomy of radioisotope lung scanning. J *Nuc Med.* 1992; 33:676-683.
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- Stein PD et al. for the PIOPED II Investigators. Multidetector Computed Tomography for Acute Pulmonary Embolism. *N Engl J Med* 2006;354:2317-27
- Scarsbrook et al. Perfusion scintigraphy: diagnostic utility in pregnant women with suspected pulmonary embolic disease. *Eur Radiol* 2007;17: 2554–2560
- Roach PJ et al. Enhancing Lung Scintigraphy With Single-Photon Emission Computed Tomography. *Seminars in Nuclear Medicine* 2008, 38:441-449

DOMAIN 3	PAEDIATRIC NUCLEAR MEDICINE
Theme 3.1	Diagnostic and Therapeutic
Learning Objective 3.1.1	Describe the basic principles of paediatric nuclear medicine
Standard	I

Knowledge	Skills
• outline the basic normal physiology of development in organ systems • recognise the differences that occur in the normal physiology of growth and development, and the pathophysiology of common paediatric diseases • determine appropriate studies in paediatric patients and the techniques required • discuss the requirements of paediatric nuclear medicine procedures and the amount of radiation the patient will receive with the patient and/or parent.	• communicate clearly to patients, parents, or carers what the test involves, any risks and precautions • undertake sedation of paediatric patients so nuclear medicine procedures can be performed adequately • advise referring clinicians regarding the role of nuclear medicine studies in paediatrics • refer the more complex and less frequently performed studies to centres with recognised paediatric nuclear medicine expertise.

DOMAIN 3	PAEDIATRIC NUCLEAR MEDICINE
Theme 3.1	Diagnostic and Therapeutic
Learning Objective 3.1.2	Assess musculoskeletal disorders
Standard	I

Knowledge	Skills
• discuss the normal physiology of skeletal growth plates in infants, children, and adolescents, including the time of fusion of the plates • describe the most common sites of pathology in osteomyelitis and bone metastases in malignancy, particularly neuroblastoma • discuss the role, benefits, and limitations of pinhole imaging, SPECT, and SPECT/CT imaging in the imaging of musculoskeletal disorders in paediatric patients, including appropriate imaging protocols and strategies to minimise radiation dose.	• assess children with bone or joint pain and determine the appropriate nuclear medicine studies to be employed • supervise and interpret bone, gallium scans and F-18 FDG PET in musculoskeletal infection in paediatrics, particularly for osteomyelitis, septic arthritis, and other inflammatory disorders • supervise and interpret bone scans in ischaemic conditions such as avascular necrosis and Perthe's disease • supervise and interpret bone scans in trauma and non-accidental injury in paediatric patients • supervise and interpret bone scans in musculoskeletal malignancy.

DOMAIN 3	PAEDIATRIC NUCLEAR MEDICINE
Theme 3.1	Diagnostic and Therapeutic
Learning Objective 3.1.3	Assess genitourinary disorders
Standard	I

Knowledge	Skills
• describe the development of renal function, glomerular filtration rate (GFR) and effective renal plasma flow (ERPF), in utero, neonatal period to adult period • describe and compare the various diuretic renal scan techniques used for investigating dilatation of the urinary tract • discuss the application of radionuclide cystograms, both direct and indirect methods, in vesico-ureteric reflux.	• advise referring clinicians on the roles of renal scans and ultrasound and other radiological techniques in paediatric renal disorders • supervise and interpret the various diuretic renal scan techniques used for investigating dilatation of the urinary tract • supervise and interpret renal parenchymal scanning in paediatric patients with urinary tract infection, including scarring and acute pyelonephritis • assess renal vein thrombosis, infarction, and renal transplantation in paediatric patients using renal scans • assess congenital renal abnormalities, in particular duplication abnormalities, multicystic, and polycystic kidneys, in paediatric patients using renal scans • supervise and interpret direct radionuclide cystograms.

DOMAIN 3	PAEDIATRIC NUCLEAR MEDICINE
Theme 3.1	Diagnostic and Therapeutic
Learning Objective 3.1.4	Assess GI disorders
Standard	A

Knowledge	Skills
• discuss the role of nuclear medicine in diagnosing biliary atresia in neonates • discuss the role of hepatobiliary scans in the assessment of cholecystitis • recognise the role of labelled white blood cell studies for the diagnosis of IBD in children and adolescents.	• supervise and interpret nuclear medicine studies in assessing swallowing, gastro-oesophageal reflux, gastric emptying and pulmonary aspiration • supervise and interpret the nuclear medicine studies for assessing GI bleeding in children • supervise and interpret hepatobiliary scanning in the investigation of jaundice in the neonatal period and jaundice in older children • supervise and interpret labelled white blood cell scans in the management of IBD in childhood • supervise and interpret hepatobiliary scans in liver transplantation in children.

DOMAIN 3	PAEDIATRIC NUCLEAR MEDICINE
Theme 3.1	Diagnostic and Therapeutic
Learning Objective 3.1.5	Assess infection and inflammation
Standard	A

Knowledge	Skills
• discuss the normal distribution of bone, Ga-67, and labelled white blood cell studies in paediatric patients • explain which technique is preferred in the investigation of acute and chronic infections • explain which technique is preferred in the neutropaenic patient • discuss the role, benefits, and limitations of SPECT and SPECT/CT imaging in the imaging of infection and inflammation in paediatric patients, including appropriate imaging protocols and strategies to minimise radiation dose.	• supervise and interpret bone, Ga-67 and F-18 FDG PET scans in the investigation of infections and PUO.

DOMAIN 3	PAEDIATRIC NUCLEAR MEDICINE
Theme 3.1	Diagnostic and Therapeutic
Learning Objective 3.1.6	Assess thyroid disease
Standard	I

Knowledge	Skills
• describe the role of the thyroid scan and ultrasound in the investigation of a neck mass in childhood with referring clinicians • discuss the role of the thyroid scan in the neonate with hypothyroidism.	• supervise thyroid scans and interpret the various scan patterns that arise in relation to aplasia, dysplasia, ectopic, lingual gland, and dyshormonogenesis in the neonatal period • supervise and interpret thyroid scans in hyperthyroidism in children and adolescents • supervise, perform, and interpret radioiodine therapy and post therapy scans in thyroid malignancy in children and adolescents.

DOMAIN 3	PAEDIATRIC NUCLEAR MEDICINE
Theme 3.1	Diagnostic and Therapeutic
Learning Objective 3.1.7	Assess pulmonary disease
Standard	A

Knowledge	Skills
• discuss the role of pulmonary nuclear medicine techniques in the evaluation of congenital pulmonary and cardiac abnormalities.	• supervise and interpret ventilation and perfusion lung scans in paediatric patients with pulmonary artery atresia and stenosis • interpret ventilation and perfusion lung scans in children with congenital pulmonary emphysema, lung cysts, and sequestration of the lung for clinicians managing these cases.

DOMAIN 3	PAEDIATRIC NUCLEAR MEDICINE
Theme 3.1	Diagnostic and Therapeutic
Learning Objective 3.1.8	Assess malignancy
Standard	A

Knowledge	Skills
• discuss the use of F-18 FDG PET in paediatric solid tumours with referring clinicians • discuss the use of PET in paediatric brain tumours with referring clinicians • discuss the role of nuclear medicine in investigating complications of treatment in paediatric oncology, e.g. infection with referring clinicians • discuss the role of radionuclide I-131 therapy in thyroid cancer and MIBG therapy in neuroblastoma with referring clinicians • discuss the role, benefits and limitations of SPECT and SPECT/CT imaging in the imaging of malignancy in paediatric patients, including appropriate imaging protocols and strategies to minimise radiation dose.	• supervise and interpret bone and MIBG scans in neuroblastoma • supervise and interpret bone and F-18 FDG PET scans in the assessment of paediatric and adolescent bone and soft tissue sarcoma • supervise and interpret bone and F-18 FDG PET scans in the assessment of paediatric and adolescent lymphoma • supervise and interpret bone scans in acute leukaemia • supervise, perform, and interpret post therapy scans in children and adolescents who are receiving radionuclide therapy, i.e. thyroid cancer and neuroblastoma.

DOMAIN 3	PAEDIATRIC NUCLEAR MEDICINE
Theme 3.1	Diagnostic and Therapeutic
Learning Objective 3.1.9	Assess neurological disease
Standard	A

Knowledge	Skills
• discuss the application of CSF flow studies performed for the investigation of hydrocephalus with referring clinicians • assess cases to determine the need for CSF shunt patency studies • discuss the role of cerebral blood flow SPECT studies in focal epilepsy • discuss the application of nuclear medicine studies for the investigation of cerebral brain tumours in children with referring clinicians.	• supervise, perform, and interpret CSF shunt patency studies • supervise and interpret cerebral blood flow SPECT studies in vascular disorders in paediatrics, including stroke and Moya Moya disease and determination of brain death • supervise and interpret PET studies in the diagnosis and detection of residual tumour and recurrence in cerebral tumours.

DOMAIN 3	PAEDIATRIC NUCLEAR MEDICINE
Theme 3.1	Diagnostic and Therapeutic
Learning Objective 3.1.10	Assess congenital cardiac disease
Standard	A

Knowledge	Skills
• discuss the role of cardiac nuclear medicine techniques in the evaluation of congenital left to right and right to left cardiac shunts • discuss the role of myocardial perfusion nuclear medicine techniques in the evaluation of congenital and acquired paediatric cardiac abnormalities.	• assess the need for myocardial perfusion studies in patients with suspected transposition of the great arteries, tetralogy of Fallot and myocardial vascular disorders, such as Kawasaki's disease, and anomalous coronary artery disease • supervise and interpret left to right cardiac shunts, gated cardiac blood pool scans, and myocardial perfusion scans in children and adolescents.

Theme 3.1 Teaching and Learning Resources

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- Hornung TS, Bernard EJ, Jaeggi ET, Howman-Giles R, Celemajer DS, Hawker R. Myocardial Perfusion Defects and Associated Ventricular Dysfunction in Congenitally Corrected Transposition of the Great Arteries. *Heart* 80(4): 322-326,1998
- Bolton, R, *People Skills* 1987. Brookvale, Australia: Simon and Schuster.
- Donohue, K.J., Brill, A.B., Brill, D.R., Conway, J.J., Silberstein, E.B., & Whipple, C. (1996). How to be an effective risk communicator. *J Nucl Med*, 37(6), 23N-26N.

DOMAIN 4	THERAPY
Theme 4.1	Therapeutic Nuclear Medicine
Learning Objective 4.1.1	Treat hyperthyroidism and other benign thyroid disease with I-131
Standard	I

Knowledge	Skills
• describe causes of hyperthyroidism and treatment options, including selection of patients for I-131, drug therapy or surgery • describe the principles of I-131 therapy • discuss role of I-131 in euthyroid patients with symptomatic multi-nodular goitre • discuss the risks and benefits of I-131 therapy, including implications of therapy in females of child-bearing age and patients with thyroid eye disease • discuss legislative requirements for safe delivery of I-131.	• assess suitability for I-131 therapy following history and clinical examination and review of relevant pathology and imaging • determine appropriate dose of I-131 • obtain informed consent, including advice about fertility and contraception • supervise and perform administration of I-131 for benign thyroid disease.

DOMAIN 4	THERAPY
Theme 4.1	Therapeutic Nuclear Medicine
Learning Objective 4.1.2	Treat thyroid cancer with I-131
Standard	I

Knowledge	Skills
• discuss the epidemiology, pathophysiology, staging, prognosis, and treatment options of differentiated thyroid cancer • describe the principles of I-131 therapy • discuss the different treatment options including surgery, I-131 and external beam radiotherapy, for local and metastatic disease • discuss the role of thyroid remnant ablation, including the role of post operative imaging • discuss the physiology of recombinant TSH used in conjunction with I-131 ablation, and discuss its advantages and limitations compared with thyroid hormone withdrawal • define the risks and benefits of I-131 therapy for thyroid cancer	• assess suitability for I-131 therapy, including determination of appropriate dose • recognise contraindications to I-131 therapy • prepare patient for I-131 therapy • explain procedure and obtain informed consent, including appropriate advice about fertility and contraception • give advice on further management, including recommencement of thyroid hormone and surveillance monitoring with periodic thyroglobulin, ultrasound, and radioiodine scans • supervise and perform administration of I-131 for thyroid cancer • interpret post therapy I-131 scans

DOMAIN 4	THERAPY
Theme 4.1	Therapeutic Nuclear Medicine
Learning Objective 4.1.2	Treat thyroid cancer with I-131

• discuss controversies relating to I-131 radionuclide therapy, including treatment of patients with low bulk disease and thyroid stunning • discuss follow-up of patients with thyroid cancer, including role of thyroglobulin and imaging • discuss legislative requirements for safe delivery of I-131 • discuss the role of F-18 FDG PET scans in the evaluation of thyroid cancer and explain how uptake of I-131 and F-18 FDG varies according to the degree of tumour dedifferentiation.	• supervise and interpret F-18 FDG PET scans in patients with dedifferentiated thyroid cancer.

DOMAIN 4	THERAPY
Theme 4.1	Therapeutic Nuclear Medicine
Learning Objective 4.1.3	Treat bone pain due to metastatic disease with nuclear medicine therapies
Standard	I

Knowledge	Skills
• describe the principles of radionuclide therapy in treating patients with metastatic bone pain • define the benefits and risks of Sr-89 or Sm-153 EDTMP therapy • discuss the appropriateness of Sr-89 therapy over Sm-153 EDTMP therapy in various clinical settings • discuss how to determine response, including use of a pain diary, and timing of possible repeat treatments • discuss legislative requirements for safe delivery.	• assess suitability for therapy following history and clinical examination, and review of imaging including Tc-99m bone scans • explain procedure, including likely outcome, duration of response and management of possible flare reaction • supervise and perform administration of radionuclide therapy for bone pain • arrange patient follow-up in consultation with their treating clinician(s).

DOMAIN 4	THERAPY
Theme 4.1	Therapeutic Nuclear Medicine
Learning Objective 4.1.4	Treat arthritis with radiation synovectomy
Standard	A

Knowledge	Skills
• describe different treatment options for inflammatory joint disease and appropriate selection of patients for radiation synovectomy • define the risks and benefits of Y-90 radiation synovectomy therapy.	• explain procedure and obtain informed consent • inject joint using sterile technique or work in collaboration with a rheumatologist or radiologist, including joint aspiration and administration of corticosteroids if indicated • give post therapy complication advice, ensure appropriate immobilisation and patient follow-up.

DOMAIN 4	THERAPY
Theme 4.1	Therapeutic Nuclear Medicine
Learning Objective 4.1.5	Treat haematological malignancy
Standard	A

Knowledge	Skills
• describe the role of P-32 therapy in treating patients with polycythemia rubra vera and essential thrombocythaemia • describe selection of patients for P-32 therapy, and advantages and disadvantages compared to other therapies • discuss the role of radiolabelled antibodies, e.g. I-131 or Y-90 labelled anti-CD20 antibodies, in the treatment of lymphoma, leukaemia, and myeloma • discuss legislative requirements for delivery of radiolabelled antibodies.	• discuss appropriate use with haematological colleagues, including at multidisciplinary team meetings • explain procedure and obtain informed consent • explain patient preparation for radiolabelled anti-CD20 antibody therapy, including conditioning with un-radiolabelled antibodies, such as rituximab, and dose selection • assess the patient for any contraindications to treatment • supervise and perform administration of radionuclide therapy for haematological malignancies • arrange follow-up, working closely with a haematologist.

DOMAIN 4	THERAPY
Theme 4.1	Therapeutic Nuclear Medicine
Learning Objective 4.1.6	Treat neuroendocrine tumours
Standard	WI

Knowledge	Skills
• describe the pathophysiology of tumours, including neuroblastoma, phaeochromocytoma, paraganglioma, and neuroendocrine tumours • describe classification of neuroendocrine tumours, including differentiation of well and poorly differentiated phenotypes • describe the role of imaging with radioiodinated MIBG, octreotide SPECT/CT, Ga-68 somatostatin-labelled PET and the complementary role of F-18 FDG PET • describe the different forms of PRRT, including different somatostatin peptides, e.g. octreotide vs. octreotate, and the utility of In-111, Y-90 and Lu-177 • describe selection of patients for I-131 MIBG and radiolabelled somatostatin therapy • describe treatment protocols, including role of radio-sensitising chemotherapy • describe indications of other treatments including surgery, chemotherapy, and radiotherapy • describe legislative requirements for safe delivery of therapy.	• assess suitability following history, clinical examination, and review of relevant pathology and imaging • discuss selection of therapy with oncology colleagues, including within a multidisciplinary team • perform dosimetry in patients undergoing radionuclide therapy for neuroendocrine tumours • explain procedure and obtain informed consent • prepare patient for therapy including use of potassium iodide for MIBG and use of reno-protective amino acid infusion for octreotate therapy • supervise and perform administration of radionuclide therapy for neuroendocrine tumours • arrange patient follow-up in consultation with their treating clinician(s).

DOMAIN 4	THERAPY
Theme 4.1	Therapeutic Nuclear Medicine
Learning Objective 4.1.7	Treat liver malignancy/metastatic disease with intra-arterial therapy
Standard	WI

Knowledge	Skills
• describe selection of patients and role for intra-arterial therapy with I-131 lipiodol and Y-90 selective internal radiation (SIR)-spheres, including use of PET, CT, and MRI • discuss the advantages and disadvantages of I-131 lipiodol vs. Y-90 SIR-spheres for treatment of intrahepatic malignancy • describe the indications and contraindications for treatment • describe likely therapeutic outcome and possible adverse effects, and compare with alternate treatments such as chemotherapy.	• supervise and interpret intra-arterial Tc-99m MAA liver lung breakthrough scans • assess patient suitability for therapy • explain procedure and obtain informed consent • administer therapy in close collaboration with an interventional radiologist • arrange patient follow-up in consultation with the treating clinician(s).

Theme 4.1 Teaching and Learning Resources

- *Nuclear Medicine in Clinical Diagnosis and Treatment*, Ell PJ and Gambhir SS (Eds), 3rd Edition, 2004, Churchill Livingston, Edinburgh
- EANM Procedure Guidelines for I-131 Lipiodol:
  http://www.eanm.org/scientific_info/guidelines/gl_radio_ther_lipiodol.pdf
- EANM Procedure Guidelines for radiation synovectomy:
  http://www.eanm.org/scientific_info/guidelines/gl_radio_synovectomy.pdf
- EANM Procedure Guidelines for P32 therapy:
  http://www.eanm.org/scientific_info/guidelines/gl_radio_ther_32p.pdf
- EANM Procedure Guidelines for radioimmunotherapy:
  http://www.eanm.org/scientific_info/guidelines/gl_radio_ther_radioimmun.pdf
- EANM Procedure Guidelines for treatment of differentiated thyroid cancer:
  http://www.eanm.org/scientific_info/guidelines/gl_radio_ther_259_883.pdf
- EANM Procedure Guidelines for treatment of refractory bone pain:
  http://www.eanm.org/scientific_info/guidelines/gl_radio_treatment.pdf
- EANM Procedure Guidelines for MIBG therapy:
  http://www.eanm.org/scientific_info/guidelines/gl_radio_ther_benzyl.pdf
- Revised American Thyroid Association Management Guidelines for
  Patients with Thyroid Nodules and Differentiated Thyroid Cancer:
  http://thyroidguidelines.net/sites/thyroidguidelines.net/files/file/ATA_DTC_Guidelines_2009.pdf
- Guidelines for the Therapeutic Administration of Strontium-89, Dept. of Human Services (VIC):
  http://www.health.vic.gov.au/environment/downloads/guidelines_strontium.pdf
- Guidelines for the Therapeutic Administration of Samarium-153, Dept. of Human Services (VIC):
  http://www.health.vic.gov.au/environment/downloads/guidelines_samarium153.pdf

ACRONYMS AND INITIALISMS

ACE	angiotensin-converting enzyme
ALARA	as low as reasonably achievable
ANZAPNM	Australian and New Zealand Association of Physicians in Nuclear Medicine
ASD	atrial septal defect
ATN	acute tubular necrosis
BMD	bone mineral density
CA	cancer antigen
CCK	cholecystokinin
CEA	carcinoembryonic antigen
CRPS	complex regional pain syndrome
CSF	cerebrospinal fluid
CT	computed tomography
CTAC	computed tomography-based attenuation correction
CTCA	computed tomography coronary angiography
CTPA	computed tomography pulmonary angiography
DISIDA	diisopropyl iminodiacetic acid
DMSA	dimercaptosuccinic acid
DOPA	dihydroxyphenylalanine
DTPA	diethylene triamine pentaacetic acid
DVT	deep venous thrombosis
EANM	European Association of Nuclear Medicine
ECG	electrocardiogram
EDTA	ethylenediaminetetraacetic acid
EDTMP	ethylenediaminetetramethylene phosphonate
EF	ejection fraction
ERCP	endoscopic retrograde cholangiopancreatography
ERPF	effective renal plasma flow
FDG	fludeoxyglucose
FES	fluoro-oestradiol

FLIPI	Follicular Lymphoma International Prognostic Index
FLT	fluorothymidine
FMISO	fluoromisonidazole
GCBPS	gated cardiac blood pool scans
GEPNET	gastroenteropancreatic neuroendocrine tumour
GFR	glomerular filtration rate
GI	gastrointestinal
GIST	gastrointestinal stromal tumour
HDP	hydroxymethane diphosphonate
HER	human epidermal growth factor receptor
IBD	inflammatory bowel disease
ICD	implantable cardioverter-defibrillator
IPI	International Prognostic Index
JSAC	Joint Specialist Advisory Committee
LBBB	left bundle branch block
LV	left ventricle
MAA	macroaggregate albumen
MDP	methylene diphosphonate
MET	methionine
MIBG	metaiodobenzylguanidine
MRI	magnetic resonance imaging
NPV	negative predictive value
PDA	patent ductus arteriosus
PE	pulmonary embolism
PERCIST	positron emission tomography response evaluation criteria in solid tumours
PET	positron emission tomography
PIOPED	prospective investigation of pulmonary embolism diagnosis
PPV	positive predictive value
PRRT	peptide receptor radionuclide therapy
PUO	pyrexia of unknown origin

RANZCR	Royal Australian and New Zealand College of Radiologists
RBC	red blood cell
RECIST	response evaluation criteria in solid tumours
RSD	reflex sympathetic dystrophy
RV	right ventricle
RVH	renovascular hypertension
SCC	squamous cell carcinoma
SIR	selective internal radiation
SPECT	single photon emission computed tomography
SNM	Society of Nuclear Medicine
SPN	solitary pulmonary nodule
SRI	somatostatin receptor imaging
SSP	stereotactic surface projections
TNM	tumour node metastasis
TRH	thyroid releasing hormone
TSH	thyroid-stimulating hormone
VSD	ventricular septal defect